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THE LIFE HISTORY OF THE NEMATODE *METABRONEMA SALVELINI* (FUJITA, 1920) PARASITIC IN THE SPECKLED TROUT, *SALVELINUS FONTINALIS* (MITCHILL), IN QUEBEC[1]

BY L. P. E. CHOQUETTE[2]

Abstract

In Quebec, the first larval stages of the spirurid, *Metabronema salvelini* (Fujita, 1920), parasitic in the speckled trout, *Salvelinus fontinalis* (Mitchill), are to be found in nymphs of the mayfly, *Hexagenia recurvata*, and in those of a species of the genus *Polymitarcys*. The fourth larval stage develops in the fish host. The third and fourth larval stages are described. The feeding of larvae-harboring nymphs of *Hexagenia recurvata* to trout resulted in the establishment of infection and development of adult worms in from 60 to 70 days.

The systematic status of *Metabronema salvelini* has been reviewed by the writer (2), who showed it to be identical to *M. (Cystidicola) hardwoodi* Chandler, 1931, *M. canadense* Skinker, 1931, and *M. truttae* Baylis, 1935. This nematode is common in speckled trout in Quebec and has been found in other localities in North America and elsewhere (3).

The spirurids differ in their biology from many parasitic nematodes in having no free-living stages. The biology of this group was reviewed by Seurat in 1916 (4). From the available knowledge of the life history of mammalian spirurids it can be assumed that the development of the forms found in fish follows a somewhat similar pattern, that is, the infective larval stage develops in arthropods which, in turn, are eaten by the fish. Although many species of spirurids have been reported from fish, knowledge of their biology is scanty. In 1931, Baylis (1) reported finding the fourth larval stage of a form which he considered to be the spirurid *Cystidicola farionis*, in *Gammarus* sp., collected in Hampshire, England. Weller, in the United States in 1938 (5), upon feeding eggs of the spirurid *Rhabdochona ovifilamenta* to the crustacean *Hyalella knickerbockeri*, reported infection of the crustacean and described the first larval stage of the nematode.

[1] *Manuscript received July 16, 1954.*

Contribution from the Institute of Parasitology, McGill University, Macdonald College, Que., with financial assistance from the National Research Council of Canada.

[2] *Research Assistant.*

[The December number of this Journal (Can. J. Zoology, 32 : 375-435. 1954) was issued November 29, 1954.]

Intermediate Hosts of *M. salvelini* in Quebec

During the summer of 1949, the writer found adult *Metabronema salvelini* in the stomach of some speckled trout from Green Lake (Argenteuil Co.) together with partially digested arthropods. The arthropods were identified as remnants of nymphs of a species of mayfly and were found to harbor a larval stage of *Metabronema*. Mayfly nymphs (*Hexagenia recurvata* Morgan and *Polymitarcys* sp.) collected on various occasions during the summer months of 1949, 1950, and 1952, also harbored these nematode larvae. Larvae were present in about 40% of the 225 *Hexagenia* nymphs collected from the Ste. Anne du Nord River (Château Beaumont Territory, Laurentide Park), while only a few of the nymphs of *Polymitarcys* collected in Grand Lac Carre, Laurentide Park, harbored the parasite.

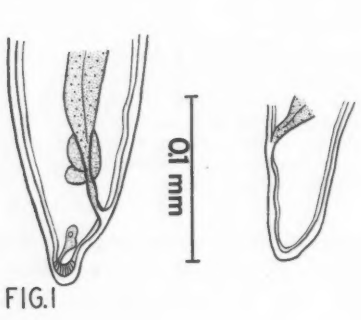
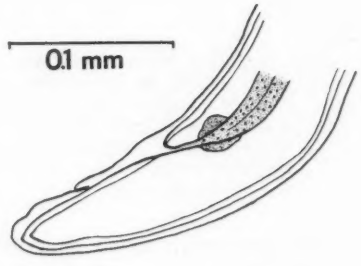


FIG. 1



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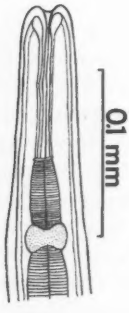

FIG. 2

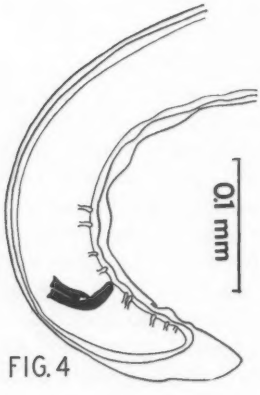

FIG. 4

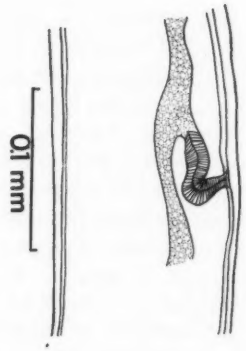

FIG. 5

Metabronema salvelini

FIG. 1. Posterior extremity of nine-day-old third stage larva (female, left; male, right) from experimentally infected trout.

FIG. 2. Anterior extremity of 40-day-old fourth stage larva.

FIG. 3. Posterior extremity of 40-day-old molting female fourth stage larva.

FIG. 4. Posterior extremity of 40-day-old molting male fourth stage larva.

FIG. 5. Vulva region of 40-day-old fourth stage larva.

Contrary to what happens in the development of mammalian spirurids, the larval stages of *Metabronema* do not encyst in the arthropod host but remain free in the body cavity. In most cases only a single larva was present, although occasionally a nymph would be found harboring two or three larvae.

The feeding of *Hexagenia recurvata* nymphs from the Ste. Anne du Nord River to parasite-free trout resulted in the establishment of infection and development of adult *M. salvelini* forms in from 60 to 70 days after initial feeding.

The Third and Fourth Larval Stages of *M. salvelini*

The third larval stage found in *Hexagenia* resembles the adult form in many respects, particularly in the morphology of its digestive tract: narrow vestibule esophagus divided into two portions—the first being muscular, shorter, lighter in color, and surrounded by the nerve ring at a short distance from its anterior extremity; the second glandular portion being much longer and darker in color. The rectum is short and provided with well-developed glandular structures. The excretory pore is situated at a short distance behind the nerve ring and it communicates by a short canal with a gland placed along the first portion of the esophagus. The sexes of the third stage larva are differentiated by the presence of a knoblike appendage on the tail of the female; in the male the tail is conical and lacks this appendage (Fig. 1). In both sexes the genital tubes are in an advanced stage of development but there are no signs of spicules in the male at this stage nor any sign of a vagina and vulva in the female. Measurements of male and female third stage larvae from *Hexagenia recurvata* are given in Table I.

When the arthropods harboring the larvae are ingested by the fish host the larvae continue to grow and undergo another molt which results in the fourth stage (Figs. 2-5). The fourth stage larva again molts and finally the young adult emerges. During this period the larva increases in size and by the end of the fourth stage the genital organs have acquired their definitive disposition. Larvae from experimentally infected fish were examined on the

TABLE I

MEASUREMENTS (IN MM.) OF THIRD STAGE LARVAE OF *M. salvelini* (FUJITA, 1920) BASED ON MENSURATION OF 7 MALE AND 10 FEMALE LARVAE FROM *Hexagenia recurvata*

	Male	Female
Total length	3.32 to 4.89	4.2 to 7.0
Length of vestibule	0.067 " 0.11	0.1 " 0.128
Esophagus:		
Length anterior portion	0.3 " 0.486	0.432 " 0.748
Length posterior portion	0.841 " 1.40	1.0 " 1.84
Total length	1.08 " 1.84	1.45 " 2.588
Nerve ring (from anterior extremity)	0.108 " 0.150	0.147 " 0.176
Excretory pore (from anterior extremity)	0.137 " 0.195	0.185 " 0.224
Length of tail	0.064 " 0.073	0.04 " 0.083

9th, 21st, and 40th days after initial infection. The genital organs were first noted after the 40th day of examination, although in the case of the male it is fair to presume that they might have been seen a little earlier had the larvae been examined before that time.

Acknowledgments

The writer wishes to express his appreciation for the help and co-operation extended to him by officers of the Department of Fish and Game, Province of Quebec, and particularly to Mr. Gustave Prévost of the Biological Bureau. The author is also indebted to Mr. G. S. Walley, Division of Entomology, Science Service, Department of Agriculture, Ottawa, who kindly examined some of the mayfly nymphs and provisionally identified them as those of *Hexagenia recurvata*.

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A TECHNIQUE FOR ASSESSING SPRUCE BUDWORM LARVAL MORTALITY CAUSED BY PARASITES[1]

By C. A. Miller[2]

Abstract

Apparent parasitism and the population trend during the larval stage of the host are the basic data for assessing budworm larval mortality caused by parasites. Apparent parasitism is estimated from samples of the host population, and three methods of obtaining this estimate within predetermined error limits are outlined. The seasonal history of the parasite is divided into a 'pre-emergence' period, when the parasite is developing within the host, and an 'emergence' period, when the host is actually killed. Percentage mortality is then based on host density at the beginning of the emergence period so the results will not be influenced by the mutual interference of other factors during the pre-emergence period. One field example illustrates the technique and its application to life tables.

Introduction

This is the third in a series of papers (10, 11) dealing with techniques used in ecological studies of the spruce budworm, *Choristoneura fumiferana* (Clem.), on the Green River Watershed in northern New Brunswick. The technique is so designed that the results obtained can be included directly in life tables for the budworm as outlined by Morris and Miller (11). It is limited to the assessment of larval mortality caused by primary parasites and, where practical, each species is considered separately. As host density is a basic factor in the assessment, the estimates of mortality can be analyzed in relation to populations of varying age and density. The final analysis, which will be undertaken at the termination of the present outbreak in the Green River area, may contribute to a better understanding of the role of parasites in budworm epidemiology.

The Expression of Parasitism

The theory and mathematics of host–parasite interactions and the balance of animal populations have been discussed by Nicholson and Bailey (12) and Thompson (20). Recently the mathematical equations set up by Nicholson and Bailey have been tested by experimental data (5). Varley (21) also tested some of these equations against observed facts in a study of the natural control of the knapweed gall-fly. However, in the study of the natural control factors affecting insect populations there is still a need for much basic ecological work and, as Solomon (17) has indicated, ". . . . such work can be adequate only if it has a quantitative basis, and it requires the best available techniques for the estimation of numbers".

Howard and Fiske (7) showed that percentages of mortality could not be combined in an estimate of total mortality. Thompson (19) pointed out the

[1] *Manuscript received August 13, 1954.*
Contribution No. 170, Division of Forest Biology, Science Service, Canada Department of Agriculture, Ottawa, Canada.
[2] *Laboratory of Forest Biology, Fredericton, New Brunswick.*

difference between 'apparent' and 'real' mortality and stated that ". . . . the mortality produced by the controlling factors as determined by the working entomologist is practically always the apparent mortality, the only exception being in studies on the effect of egg parasites". Thompson based real mortality on the initial population (egg stage) of the host and showed that major fluctuations in apparent mortality may represent only slight changes in terms of real mortality. Bess (2), although retaining Thompson's concept of apparent mortality, disagreed with the interpretation of real mortality and stated that estimates should be based on the survival (adult) population rather than the initial population. This is done by transforming an estimate of apparent mortality as a percentage value to a 'mortality/survival ratio'. For example, a 60% apparent mortality equals a mortality/survival of $60/40 = 1.50$, regardless of host density or the stage of the insect attacked. A series of such ratios can be combined to obtain the total effect on the surviving population. In an example from field observations on the gypsy moth, Bess showed that the total egg and larval mortality caused by a group of parasites gave a mortality/survival ratio of 12. He stated, "If all parasites had been absent, and the other mortality factors had accounted for the same percentage of the population as they did in the presence of the parasites, the survival population would have been increased by 12 times". The assumption contained in this statement is all-important and if the factors favoring decrease in a population form a complex relationship as suggested by Allee *et al.* (1) and Solomon (17), the application of the statement made by Bess may be invalid.

Other methods have been used in estimating the total effect of natural enemies on a population. These have included sleeve cages as a means of excluding parasites (15); insecticides with differential effects on host and parasite (3); and ants which reduce the effectiveness of parasites (4). Such methods are limited in their application. Dowden *et al.* (6) caged whole trees as a possible method of estimating bird predation in a spruce budworm infestation, and presumably, a similar technique could be used to exclude parasites that attack one particular stage of the population.

The Determination of Apparent Parasitism

The basic concept of apparent mortality defined by Thompson (19) and Bess (2) is retained by the writer. In assessing mortality in a population an estimate of the apparent mortality is generally obtained first regardless of the final method of expression. This is evident in a study of parasitism, when estimates of the apparent mortality caused by parasites, or apparent parasitism, are usually obtained from samples of the host population.

Timing of Sample

Apparent parasitism can be determined with reliability only if the sample of the host population meets certain requirements. One of these concerns the time of collecting the sample. A full knowledge of the seasonal history

of the parasite in relation to host development is essential to ensure that the maximum number of hosts has been attacked and also that no parasites have emerged from the population prior to the collection date. Special consideration must be given to parasites that attack ultimate-instar larvae when a percentage of the population has already pupated. If the sample contains larvae and pupae in the same proportion as the population, it can be analyzed directly for apparent parasitism. If, however, only larvae are collected the total number of individuals in the sample must be corrected by that percentage of the population in the pupal stage.

Estimation of Sample Size

Two other requirements of the sample are: (1) that it be representative of the population so as to provide an unbiased estimate of apparent parasitism, and (2) that it be sufficiently large to provide this estimate within acceptable error limits. For example, in 1953, two samples of 20 larvae each were collected from each of seven trees to determine the incidence of *Apanteles fumiferanae* Vier. in a mature stand (Plot G4) outside the perimeter of a severe infestation.

TABLE I

ANALYSIS OF VARIANCE: NUMBER OF PARASITES PER SAMPLE OF 20 LARVAE, PLOT G4, 1953

Source	Sum of squares	Degrees of freedom	Mean square
Total	31.2	13	
Between trees	22.7	6	3.78
Within trees	8.5	7	1.21

The number of parasites dissected from each sample was recorded and Table I shows an analysis of variance of the data. Since 'between trees' variance is not significant the mean squares for 'between trees' and 'within trees' can be pooled to get an estimate of the variance between samples. Snedecor's formula (16) can then be used to estimate the size of sample needed to establish apparent parasitism within predetermined error limits.

$$n = \frac{100^2\, t^2\, s^2}{p^2\, \bar{x}^2}$$

where

t = value of 't' at the 5% level for 13 degrees of freedom (2.16),
s^2 = variance (2.40),
p = acceptable percentage error (20%, for example),
$\bar{x}$ = mean number of parasites per sample of 20 larvae (4.64);

then, n = 13 samples.

This formula indicates that dissections of 13 samples or approximately 260 host larvae will establish apparent parasitism with an error of 20% or less (i.e., standard error about 10% of the mean).

The variance component technique as outlined by Stark (18) can also be used to estimate required sample size. It has been suggested[3] that even though the variance between trees in Table I is not significant it is at least twice the mean square of 'between samples'. Consequently, by substitution in the following formula, the required sample size can be estimated in terms of the number of samples per tree and the number of trees to be sampled.

$$\text{S.E.}_{\bar{x}} = \sqrt{\frac{\sigma s^2 + n\sigma T^2}{nT}}$$

where

σs^2 = the mean square as an estimate of the variance component within samples = 1.21,

σT^2 = the mean square as an estimate of the variance component between samples,

$$= \frac{\text{mean square for trees} - \sigma s^2}{n} = 1.29,$$

n = the number of samples per tree (20 host larvae in each),

T = the number of trees,

S.E. = set at 10% of the mean.

Calculated T for substituted n values

n =	1	2	3	5	10
T =	11	9	8	7	6
Total number of larvae in sample =	220	360	480	700	1200.

The results indicate that by collecting one, or two, samples of 20 larvae each from approximately ten trees, the incidence of *A. fumiferanae* could be determined with an error of not more than 20%.

Evidently the required sample size will change depending on the degree of parasitism. In the above example *A. fumiferanae* attacked 23% of the population. However, it was estimated by similar trial dissections that 34 samples of 20 larvae each would be required to establish the incidence of *Glypta fumiferanae* (Vier.), which attacked only 9.7% of the population on Plot G4 in 1953. These data on apparent parasitism on Plot G4 are based on dissections and do not include estimates from larval rearings.

A more rapid method of estimating the degree of parasitism in a population is by a sequential sampling plan (13). No fixed sample size is involved and the degree of parasitism can only be established within a number of classes. However, it is useful as a survey method of estimating parasitism on a number of different plots when time does not permit mass collecting and rearing of larvae.

An example of a sequential sampling plan is shown in Fig. 1. In 1953, samples of 20 larvae were collected from each of a series of plots and dissected to determine the incidence of *G. fumiferanae*. An analysis of the frequency distribution of 68 samples showed a Poisson distribution. Formulae for this type of distribution were obtained[3] and a plan evolved whereby the degree of parasitism could be shown as less than 5%, or greater than 10%; and less than 15%, or greater than 20%. In applying the plan the total number of

[3] *Personal communication. Mr. G. B. Oakland, Statistical Research and Service Unit, Ottawa.*

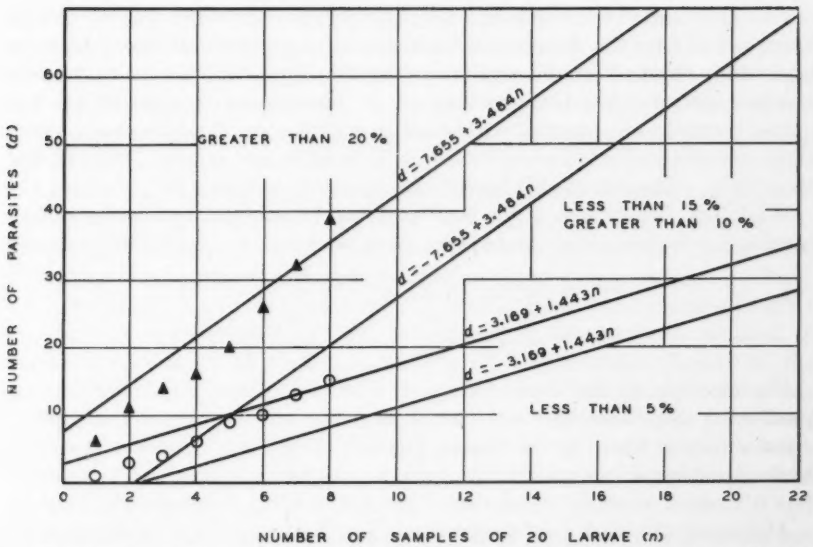

FIG. 1. Graph of sequential sampling plan. Incidence of *G. fumiferanae* on a series of plots, 1953, and *A. fumiferanae* on Plot G4, 1953, plotted in lower and upper lines respectively.

parasites dissected from successive samples is plotted as a series of points on the graph. When these points cross one of the lines, the degree of parasitism is established and sampling can be discontinued.

The following formulae for a Poisson distribution were used in obtaining the sets of lines in Fig. 1:

$$d_1 = -h_1 + sn$$

and

$$d_2 = h_2 + sn$$

where

$$h_1 = \frac{b}{\log_e m_2 - \log_e m_1} \text{ and } b = \log_e \frac{1-\alpha}{\beta},$$

$$h_2 = \frac{a}{\log_e m_2 - \log_e m_1} \text{ and } a = \log_e \frac{1-\beta}{\alpha},$$

$$s = \frac{m_2 - m_1}{\log_e m_2 - \log_e m_1},$$

h_1 and h_2 = intercepts of one set of lines,
s = slope of the line,
m_1 = the smaller mean,
m_2 = the larger mean,
α = the probability of accepting $m = m_2$ when $m = m_1$,
β = the probability of accepting $m = m_1$ when $m = m_2$.

The following values were substituted in the above formulae:

α and β = 10% for both sets of lines.

Lower lines, m_1 = 1, i.e., 1 parasite per sample of 20 larvae or 5% apparent parasitism,
m_2 = 2 or 10% apparent parasitism.

Upper lines, $m_1 = 3$, $m_2 = 4$.

Two examples of the sequential sampling plan are plotted on Fig. 1. In the upper set of lines the data on the incidence of *A. fumiferanae* used above for estimating required sample size are plotted. The graph shows that seven samples indicate that the incidence of *A. fumiferanae* is over 20%. The actual estimate of apparent parasitism was 23%. In the lower set of lines eight samples indicate the incidence of *G. fumiferanae* as over 10% but less than 15%. The actual estimate for the series of plots was 11%.

While the sample size is not fixed in a sequential plan, an average sample number can be estimated for any one set of lines with the following formulae:

$$\text{For } m = m_1, \quad \bar{n}_{m_1} = \frac{(1-\alpha)h_1 - \alpha h_2}{s - m_1};$$

$$m = m_2, \quad \bar{n}_{m_2} = \frac{(1-\beta)h_2 - \beta h_1}{m_2 - s}.$$

For example, in the lower lines if $m = m_1 = 1$ then the average sample number is approximately six, and if $m = m_2 = 2$, the average sample is approximately five. As m approaches the slope of the line the average sample number increases, and in plotting, it becomes evident that as neither line is crossed, apparent parasitism is greater than 5% but less than 10%.

McGugan (8) used a χ^2 analysis to test the estimates of parasitism by dividing the sampling plot into a number of separate collecting points. A similar analysis can be used for inter-plot comparisons where the incidence of parasitism may change as a result of host density.

Other Aspects of the Host–Parasite Relationship

In a field problem where the final objectives are life tables for the budworm, emphasis is placed on the estimation of host mortality. The objectives have excluded any detailed consideration of other aspects of host–parasite interactions. Some of these aspects are: (1) adverse effects of the host on the parasite as listed by Salt (14), (2) hyperparasitism, (3) multiparasitism, and (4) superparasitism. The adverse effects of the host on the parasite, and hyperparasitism, are more important in terms of parasite progeny than host mortality. Multiparasitism and superparasitism are as yet very rare in populations in the Green River area. At present it is assumed that these factors can be assessed by a comparison of reared and dissected samples from the host population.

Limitations of the Technique

Once the estimate of apparent parasitism is established it can be used to calculate the number of hosts killed in the population. Host mortality per unit area of branch surface (11) is the product of apparent parasitism in per cent and host density per unit area. An estimate of the number of hosts killed per unit area in one generation is of limited value, but the relationship between the number killed and host density in successive generations is important in the study of parasites as regulators of host density.

Estimates of larval mortality caused by parasites generally represent potential rather than actual values. Whether parasitism is determined by

rearing or dissection, there is interference with the natural course of events and it is not known how many parasitized larvae might actually be destroyed by other mortality factors in the field before the parasites emerge. For pupal and egg parasitism this difficulty is not encountered because an examination of the residual pupal cases or egg shells in the field provides data on actual mortality (9).

As the primary larval parasites under discussion may be classed as solitary, endoparasitic types, it can be assumed that the host is the environment of the parasite from egg to larval maturity. This is not strictly true for some of the dipterous species but it may be used as a general assumption. Therefore, the physical and biotic factors affecting the host will indirectly affect the parasite within the host. Since the host is progressively reduced in numbers as a result of these factors (Fig. 2) the potential density of the parasite will follow a similar trend if the proportion of parasitized individuals in the population remains relatively constant. In other words, the parasitized portion of the population is also reduced in numbers and some hosts, although parasitized, are actually killed by factors other than parasites in the final sequence of events.

A partial solution is obtained if the life-cycle of the parasite is split into two distinct periods: a 'pre-emergence' period from egg to larval maturity within the host and an 'emergence' period when the mature larva emerges from the host. If host mortality is estimated on host density at the end of the pre-emergence period, the reduction in the number of parasitized hosts during the period of parasite development is largely excluded from the calculations. Table II illustrates this principle in the assessment of mortality caused by *G. fumiferanae* on Plot K2, 1952. This parasite is present in second-instar budworm larvae but does not complete development until the host reaches the sixth instar.

Table II shows an estimated number of 27.3 parasitized hosts per 10 sq. ft. of foliage in the population in the fall of 1951. This number was reduced to 15.5 by the time the population was established on the new foliage in the spring of 1952. When the population reached the sixth instar in early July, the number of parasitized hosts had been reduced to 7.0. This figure is taken as the estimate of host mortality although, as indicated below, it is a potential rather than an actual value. However, 6.6 *G. fumiferanae* cocoons per 10 sq. ft. were recorded on the plot in late July, indicating a probable host mortality of 6.6 larvae per 10 sq. ft. Unfortunately, few species of parasites permit such a check from cocoon sampling.

The situation is more complex during the emergence period, which may last two weeks for parasites of the same species. The proportion of parasitized individuals in the population is no longer constant but decreases to 0, yet it is logical to assume that parasitized individuals are still being killed by factors other than parasites as in the pre-emergence period. If it could be assumed that mortality is non-differential between parasitized and unparasitized individuals at this time, the actual host mortality caused by parasites could

be assessed, but there is as yet no evidence to support the assumption. However, the difference between potential and actual mortality is limited by this method to the number of parasitized hosts killed by factors other than parasites during the emergence period.

TABLE II

ESTIMATION OF THE NUMBER OF HOSTS PARASITIZED BY *G. fumiferanae* AND THE REDUCTION IN THAT NUMBER DURING THE PERIOD OF PARASITE DEVELOPMENT, PLOT K2, 1952

Parasite stage	Host stage	Host density*	No. of parasitized hosts†	Time	Mortality factors affecting population
Egg	Instar II	195	27.3	Sept.	
					Mortality in hibernacula
	Instar II	164	22.9	May	
					Spring dispersal during emergence from hibernacula
	Instar III	111	15.5	June 1	
					Miscellaneous
	Instar IV	103	14.4	June 17	
					Predation and other factors. Emergence of *A. fumiferanae*
	Instar V	88	12.3	June 24	
					Predation, etc.
Larval maturity	Instar VI	50	7.0	July 3	
Parasite emergence from host				July 3–10	
Parasite cocoons‡				July 10	

* *Number per 10 sq. ft. of foliage.*

† *Based on apparent parasitism of 14%, and assuming no differential mortality as between parasitized and non-parasitized individuals.*

‡ *Parasite cocoon density per 10 sq. ft. on July 25 = 6.6.*

Example from Field Data

The following example of assessing larval mortality caused by parasites is taken from the records of Plot G4-P, 1951. The data on larval population trend were obtained from successive sampling of a group of five codominant balsam fir, *Abies balsamea* (L.) Mill. A wooden platform, approximately 30 ft. from the ground, was constructed within the crowns of these trees to facilitate the collection of sample foliage. All living larvae and the total number of pupae were recorded and graphed as shown in Fig. 2. The curve is fitted free-hand rather than mathematically and the relationship of population trend to time and host development is indicated. The total number of hosts collected and the apparent parasitism are shown in Table III. The dipterous parasites that attack late sixth-instar larvae and emerge from larvae or pupae are summarized as a group because of their lesser importance.

A general picture of the critical periods in the life-cycle of the parasites under consideration in relation to host development is shown in Fig. 3. These are: (1) the period when the host is attacked, (2) the period of development within the host, and (3) the period of emergence from the host when the host is actually killed. The calendar dates will, of course, vary from year to year.

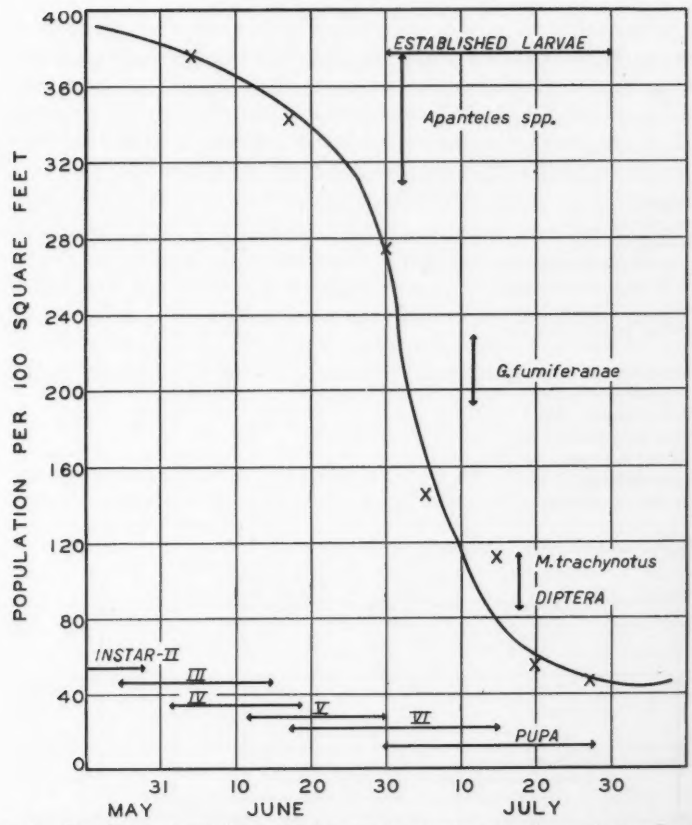

FIG. 2. Population trend from third-instar larvae to end of pupal stage on Plot G4-P, 1951.

The data in Fig. 3 were obtained by rearing periodic samples collected at short intervals throughout the period of larval development. The proportion of each collection containing parasites was then calculated in terms of apparent parasitism and plotted over the collection date.

Fig. 3 indicates the end of the pre-emergence periods for the parasites listed in Table III. These approximate the following periods of host development and calendar dates:

A. fumiferanae	Peak of Instar IV	June 17
G. fumiferanae	Peak of Instar VI	July 3
M. trachynotus *G. interrupta* Diptera complex	Late Instar VI	July 10

Host density on these dates, as a basis for estimating potential host mortality, is obtained from Fig. 2. Sampling can be limited to the three periods of host development noted above in place of the more intensive method shown in Fig. 2.

TABLE III

ESTIMATION OF APPARENT PARASITISM FROM HOST SAMPLES, PLOT G4-P, 1951

Parasite species	Hosts collected	Parasites recovered	Apparent parasitism (%)
Hymenoptera:			
Apanteles sp. (26)*	470	1	
Apanteles sp. (51)	470	2	
Apanteles fumiferanae Vier.	470	92	
Total *Apanteles* spp.	470	95	20.2
Glypta fumiferanae (Vier.)	907	145	16.0
Meteorus trachynotus Vier.	260	44	16.9
Diptera:			
Gymnophthalma interrupta (Curr.)	188	2	1.1
Diptera complex:	261	10	3.8
Aplomya caesar (Ald.)			
Phryxe pecosensis (Tns.)			
Madremyia saundersii (Will.)			
Lypha setifacies (West.)			
Omotoma fumiferanae (Tll.)			

* *Species identification numbers.*

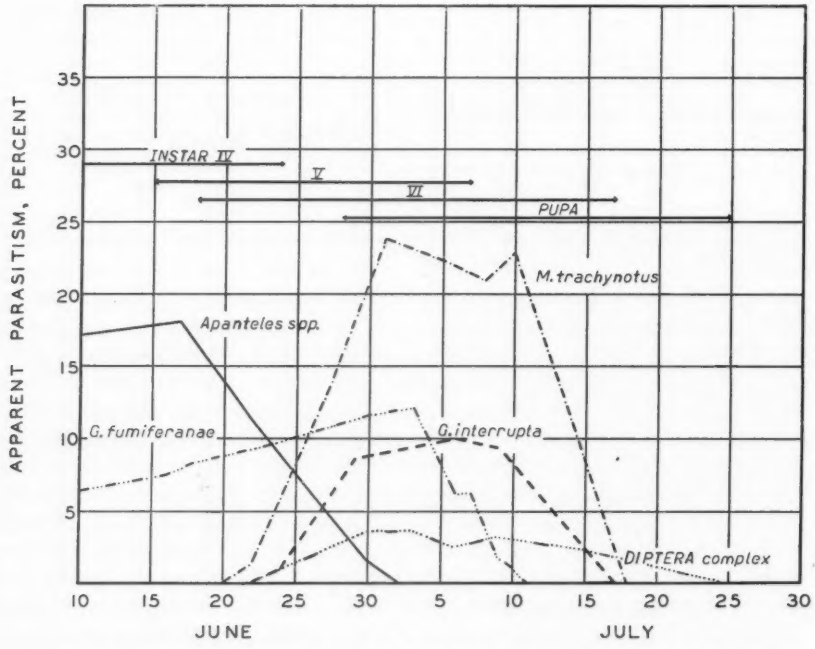

FIG. 3. Presence of primary larval parasites in a budworm population in relation to host development and time.

Table IV, column 2, shows host density per 100 sq. ft. of foliage at the end of the pre-emergence period for each parasite. Potential host mortality is then calculated as the product of apparent parasitism and host density. By summing column 3 the total larval mortality caused by all parasites is found. It is evident that other larval parasites can be included in this type of table to take care of differences in parasite complex in different populations.

The rate of mortality caused by each parasite or group of parasites can be estimated from the data in column 3 by a number of methods depending on the information desired. For example, Thompson's 'real mortality' would be based on the initial or egg population, and a 'mortality/survival ratio' on the survival or adult population. In a life table, the third- to the sixth-instar period can be grouped as one age-interval and the rate of mortality for all larval parasites based on the third-instar population.

TABLE IV

ESTIMATION OF POTENTIAL LARVAL MORTALITY AND RATE OF MORTALITY, PLOT G4-P, 1951

Parasite species	Apparent parasitism (%) (1)	Host density per 100 sq. ft. (2)	Potential larval mortality (3)	Rate of mortality based on Instar III population (4)
Apanteles spp.	20.2	350	71.0	18.7
G. fumiferanae	16.0	230	37.0	9.7
M. brachynotus	16.9	115	19.0	5.0
G. interrupta	1.1	115	1.3	0.3
Diptera complex	3.8	115	4.4	1.2
Total			132.7	35

Total mortality based on Instar III population:

$$\frac{\textit{Total mortality}}{\textit{Instar III population}} \times 100 = \frac{132.7}{382} = 35\%.$$

Discussion and Summary

The principal aims in the present study of parasites in the Green River area are: (1) to determine the relative importance of larval parasites in relation to other mortality factors in budworm epidemiology, and (2) to compare the common species in the larval parasite complex as possible regulators of host density. An analysis of life tables for many generations of the budworm in different environments should fulfill these objectives.

In a life table for the spruce budworm it is necessary to determine the mortality caused by parasites during the egg, larval, and pupal stages. This determination is facilitated in the egg and pupal stages by two factors: (1) each stage can be treated as one age-interval with one estimate of population

density, and (2) egg shells and pupae, or pupal cases, are retained on the foliage of the host tree as evidence of the fate of the population. Apparent parasitism can therefore be determined from a sample of this evidence. In the egg stage the sample is obtained after eclosion, when parasitized eggs are readily separated from the otherwise empty egg shells. Pupal samples are collected when 90 to 100% of the adults have emerged, and dead or parasitized pupae are found intact on the foliage.

The larval stage is a more dynamic period of host development and is subject at times to a very high death rate. The impracticability of treating each instar as a separate age-interval and, in particular, the continual change in population density are the main difficulties in assessing larval mortality caused by parasites. Some of these difficulties can be eliminated by estimating host mortality as the product of apparent parasitism and host density at the time when the parasite starts to kill the host. This involves the determination of apparent parasitism within reasonable error limits, a knowledge of parasite development in relation to host development, and the population density of host larvae at certain critical periods.

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A REVISION OF THE NEARCTIC CTENISCINI (HYMENOPTERA: ICHNEUMONIDAE)

I. *EUDIABORUS* KERRICH AND A NEW GENUS[1]

By W. R. M. Mason[2]

Abstract

A key to distinguish the seven Nearctic genera of the tribe Cteniscini (Hymenoptera: Ichneumonidae) is presented. The genus *Eudiaborus* Kerrich is discussed in detail with descriptions of, and a key to, 14 Nearctic species. Nine new specific, and three new subspecific, names are proposed. One species, formerly known only in the Old World, is reported from North America. A new genus and its two new species are described.

Introduction

This work is based largely on the material in three collections: the Canadian National Collection[3], the Townes Collection, and that of the United States National Museum. The following is a complete list of collections studied, with abbreviations by which they are referred to in the text: Canadian National Collection, Ottawa, Canada (CNC); collection of H. & M. Townes, Raleigh, N.C. (Townes); U.S. National Museum, Washington, D.C. (USNM); Cornell University, Ithaca, N.Y. (CU); Museum of Comparative Zoology, Cambridge, Mass. (MCZ); University of Minnesota, St. Paul, Minn. (Minn); Academy of Natural Sciences, Philadelphia, Pa. (ANSP); Illinois Natural History Survey, Urbana, Ill. (Ill); California Academy of Sciences, San Francisco, Calif. (Calif); University of Kansas, Lawrence, Kans. (Kans); University of Alberta, Edmonton, Alta. (Alta); Oregon State College, Corvallis, Oreg. (Oreg); Iowa Wesleyan College, Mount Pleasant, Iowa (Iowa); American Museum of Natural History, New York, N.Y. (AMNH); Patuxent Research Refuge, Bowie, Md. (PRR); University of Syracuse, Syracuse, N.Y. (Syr); collection of R. R. Dreisbach, Midland, Mich. (Dreisbach); collection of R. T. Mitchell, Bowie, Md. (Mitchell); collection of H. H. Swift, New York, N.Y. (Swift).

The types of all Cteniscini available in North America, except that of *Rhimphales erythrogaster* Viereck, were examined.

I agree with views on generic nomenclature expressed by Kerrich (1) in his excellent discussion.

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[2] *Agricultural Research Officer, Systematic Entomology Unit, Entomology Division, Ottawa Canada.*

[3] *A large part of the material upon which this revision is based was collected by the writer and others on the Northern Insect Survey on behalf of the Defence Research Board, Department of National Defence.*

A few new or specialized morphological terms used in this paper may need explanation. For the wings the Gahan and Rohwer nomenclature is followed. Puncturation is referred to in two ways. The size of individual punctures is referred to as coarse or fine. *Coarse* punctures are those easily seen with a hand lens whereas *fine* ones are not. The coarse punctures are of the order of 0.02 mm. in diameter, and the fine ones are about one-quarter of this. Punctures separated by about twice their own diameters or less are referred to as *dense;* those separated by greater intervals are called *sparse.* These standards are not applied to *Exenterus*, in which the puncturation is of quite a different order of magnitude. An elevated ridge at the extreme lateral margin of the mesonotum is here called the *mesonotal flange* (Figs. 11, 12). An upwardly projecting tongue lying immediately behind, and almost contiguous with, the posterior end of this flange is called the *axillary tongue.* It is believed to be part of the lateral extensions of the scutellum. The mesonotal flange is often developed into a laminate structure, and in such cases the axillary tongue is also long. Rarely a tentlike ridge lies above a groove mesad to and adjoining the posterior portion of the mesonotal flange. In several genera the lateral carinae of the petiole are produced laterally at the base into lobes called *auriculae:* such petioles are called *auriculate.* The subgenital plate is frequently folded along the midapical line and the apex produced into a fine point, or mucro (Fig. 17). In *Eudiaborus* the third valvulae are usually hollowed ventrally at the apex. The excavated part is lightly sclerotized and set with short, erect bristles. Because of a fancied resemblance in lateral view to a short, very stout leg, such valvulae are called *geniculate* (Fig. 17). In *Exyston* and *Smicroplectrus* the third valvulae are similarly hollowed but do not have the appearance of a leg. These valvulae are called *vomeriform* from a fancied resemblance to the vomerine bones of vertebrates. Valvulae of the primitive shape are referred to as *simple* (Fig. 33). The egg is typical of the Tryphoninae in bearing a stalk. At its distal end the stalk bears a hygroscopic body of widely variable size called the *foot* or *anchor* (Figs. 8, 9, 10).

The Cteniscini appear to be most closely related to the tribe Tryphonini. *Cteniscus* and *Polyblastus*, however, are not so closely related as former authors have believed. *Cteniscus* has a very highly modified egg-structure and very different genitalia. In purely somatic characters, *Exyston* and *Eudiaborus* are just as closely related to *Polyblastus* (*Polyblastus*) as is *Cteniscus;* but in genitalic and egg characters *Polyblastus* is most closely related to *Exyston* and a little less closely to *Eudiaborus.*

In the tribe two lines of descent are evident. The first is represented by the genera *Exyston* and *Smicroplectrus.* In this line the subtegular ridge is modified, the abdominal tergites are strongly arched, the subgenital plate is reduced, the ovipositor is thin and straight to near the apex, and the egg is typically subpyriform. The most primitive members of this line are found in the Old World. *E. pratorum* (Woldst.) and *S. jucundus* (Hlgr.) are good examples of generalized species.

The other line is represented by *Eudiaborus*, *Acrotomus*, *Anisoctenion*, *Cteniscus*, and *Exenterus*. In these genera the subtegular ridge remains simple, the subgenital plate is strongly developed and often apically pinched, the ovipositor is usually thick and decurved throughout its length, and the eggs and their stalks and anchors are often highly modified. *Eudiaborus pyelechus* n. sp., *Acrotomus rufus* (Prov.), *Cteniscus flavicoxae* Cress., and *Exenterus tricolor* Rmn. are examples of generalized species. Further ideas of phylogeny are discussed under the respective genera.

The tribe is almost entirely confined to the Holarctic region. The only exceptions are a few species of *Acrotomus*, which extend into the higher mountainous regions of the oriental tropics. This genus is confined, with one exception, to the Old World. Almost all Cteniscini occur in humid forested regions, the only notable exceptions being a few species of *Exyston* and *Exenterus*.

Very little is known of the habits of these insects except in the genus *Exenterus*. As far as is known, all are parasitic upon larvae of Tenthredinidae except *Exenterus*, which appears to be confined to Diprionidae. The eggs are generally placed in the neck region of the host larva, the anchor being attached internally and the egg itself entirely external as in most species, or partly external as in *Cteniscus* and some species of *Exenterus*. Hatching is delayed until after the host larva has spun its cocoon. The parasite develops externally within the host cocoon where it overwinters.

A discussion of the characters of the subfamily, with a key to the tribes is provided by Townes and Townes (5). Members of the Cteniscini may be distinguished from all other Ichneumonidae by the combination of one apical spur on the middle tibia and no apical spurs on the hind tibia. In a few species the hind tibia bears a small apical projection, but this is not a true spur nor is it any longer than the apical width of the tibia. The body is stout to moderately stout, with a short ovipositor and usually a completely areolated propodeum. Several habitus sketches are included in partial compensation for the lack of exact characters.

Species Incorrectly Assigned to Cteniscini

Cteniscus crassipes Prov., 1886, Addit. Faune Canada, Hymen., p. 109.

The type of this species is lost, but the description fits a species of *Colpotrochia* exactly, and it has been referred to that genus by Townes (4). The common habit of the Metopiinae of dying with tibial spurs closely appressed to the basitarsus may account for Provancher's placement of the species.

Tryphon rufigaster Prov., 1886, Addit. Faune Canada, Hymen., p. 104.

This species was referred to *Cteniscus* by Townes (3), on the basis of the Gahan and Rohwer lectotype at the Museum of Public Instruction, Quebec. The true type, however, is in the Canadian National Collection at Ottawa and has been examined by M. Noel-M. Comeau, Curator of the Provancher collection, who has confirmed its identity. It is a species of *Ipoctoninus* (New combination).

Key to Genera of Nearctic Cteniscini

1. Subtegular ridge simple, i.e., with a single horizontal carina, sharp posteriorly but rounded anteriorly, and subtending a short vertical carina on the anterior pleural wing process (Fig. 1).....3

Subtegular ridge either with an additional longitudinal carina below the posterior half of the main horizontal carina, or with the horizontal carina extending upward to touch the tegula when in the closed position and concealing a deep groove above (Figs. 2–4); metanotum bearing a pair of small, piliferous lobes (like cenchri of sawflies); petiole always strongly auriculate basally.....2

2. Length of petiole about 1.5 times apical width; propodeum abruptly declivate behind apical carina; subtegular ridge usually single and extending to touch the tegula in closed position (Figs. 2, 3). If subtegular ridge double (Fig. 4), as in *Exyston*, then petiole and propodeum both strongly rugose and carinate, and petiole with strongly projecting apicolateral angles. Tarsal claws pectinate.....*Smicroplectrus* Thom.

Petiole seldom less than twice as long as wide apically; subtegular ridge always double as described above; propodeum rather evenly rounded and without very strong carinae; tarsal claws simple.....*Exyston* Schiodte

3. Lower mandible tooth longer and larger than the upper. (In the only Nearctic species *ornatus* (Walsh), the petiole is short, broad, auriculate, and together with the second and third tergites, longitudinally aciculate).....*Acrotomus* Foer.

Mandible teeth equal or subequal; never with aciculations described above.....4

4. Petiole always short and basally auriculate, broadening suddenly basally and little thereafter; body either very coarsely punctate or the second tergite with a pair of small, divergent, basal grooves.....6

Petiole not basally auriculate but broadening gradually from base to apex, often slender; body never coarsely punctate; second tergite rarely with such basal grooves, but if these present, the petiole long, slender, and evenly tapered.....5

5. Egg with a single stalk; female subgenital plate sharply folded; ovipositor long and thin; petiole slender, about twice as long as wide apically; second tergite, except in some males, with a pair of grooves as in *Eudiaborus*; body smooth and very finely sparsely punctate; legs long and slender; head subcuboid, much wider than the thorax.....*Orthomiscus* n.g.

Egg with a double stalk; female subgenital plate flat; ovipositor short and thick; petiole seldom so slender; second tergite never with such basal grooves.....*Cteniscus* Hal.

6. Entirely very coarsely and densely punctate; second tergite without divergent basal grooves; color in all Nearctic species black and yellow.....*Exenterus* Htg.

Much less coarsely and densely punctate, especially on the mesonotum and apical tergites; second tergite always with a pair of short basal grooves which diverge posteriorly; often red or with red legs.....*Eudiaborus* Kerr.

Eudiaborus Kerrich

Diaborus auct., not of the genotype.

Eudiaborus Kerrich, 1952. Brit. Museum (Natural History) Entomol. Bull. 2 : 315.

Type: *E. pallitarsis* (Thom.). Original designation.

Most species of this genus may be distinguished at once by the unique color pattern of the abdomen, i.e., a series of median apical, subtriangular, yellow spots on the tergites with the remainder of the tergites black or sometimes red. In all species the combination of short, broad, basally auriculate petiole and pair of small divergent basal grooves on tergite two is diagnostic. Most characteristic is the apical lip or hook of the female subgenital plate and its usual boatlike shape.

Phylogeny

A rather close relative is the only Nearctic species of *Acrotomus*, *A. ornatus* (Walsh). Mr. Kerrich (in litt.) states that this species holds a rather primitive

position in the genus compared to Palaearctic forms. The general habit, and especially the form of the ovipositor and egg, is very close to that of *E. flavicircus* n. sp. and *E. pyelechus* n. sp.

Cteniscus and the *Exyston-Smicroplectrus* complex are less closely allied.

The derivation of *Eudiaborus* is obscure. Present scanty knowledge indicates only that primitive members of this genus are as generalized as any Cteniscini and show no signs of derivation from any other extant cteniscine genera.

In the genus two broad lines of descent are apparent. First, the *vitticollis* group consists of four species united by the common characters of a decurved ovipositor and nongeniculate third valvulae. Two subgroups are evident. One, represented by *E. pyelechus*, is extremely primitive. In this the third valvulae are simple (Fig. 26) and the subgenital plate is merely bent into a troughlike form with only the beginnings of an apical lip (Fig. 25). The second subgroup, represented by *E. vitticollis* (Cresson) and *E. flavicircus*, has a pinched subgenital plate but very highly modified third valvulae (Figs. 14, 30, 32). The Holarctic species *E. glutiniatus* (Roman) probably belongs to the latter subgroup but lacks the high degree of specialization of the third valvulae (Fig. 19, 21), and shows a different type of distribution, being circumpolar, whereas the other species of the *vitticollis* group are confined to eastern North America.

Second, the *scalaris* group includes the rest of the genus, about 20 known species. In this line a number of evolutionary stages may be seen. The ovipositor is of characteristic form (Fig. 18), being abruptly tapered a little distad of the middle, never decurved, but straight or curved upward. It is here referred to as the *scalaris* type of ovipositor. In all but the most primitive species the third valvulae are geniculate (Fig. 17). The most primitive species, *E. eximius* n. sp., has simple third valvulae and a subgenital plate merely gibbous below with a broad apical lip (Fig. 33). More advanced species, such as *leptonyx*, *devius*, and *nigrocephalus*, have geniculate third valvulae and a shallowly boat-shaped subgenital plate with a very narrow apical lip (Figs. 35–43). The most specialized species, *scaphuloides*, *luminosus*, *similis*, *pulchellus*, *maculiventris*, *promediatus*, *dorsalis*, and the Palaearctic species *E. pallitarsis* (Thom.) have geniculate third valvulae and a distinct, deeply boat-shaped subgenital plate upon which the lip is reduced to a small hooklike structure here called a *mucro* (Figs. 44–63).

Description

Head broader than long; clypeus one-third to two-fifths as long as wide; eyes obviously divergent below, but rarely subparallel; malar space shorter than basal width of mandible; temple slightly narrower than, to twice as broad as, eye in lateral view; occipital and hypostomal carinae complete and uniting a little above mandibular condyle, but neither doubled nor strongly raised and laminate; mandible simple, teeth equal in size and length.

Mesonotal grooves present, short and well defined basally but present as shallow depressions to behind middle of scutum; subtegular ridge simple (Fig. 1); prepectus simple, the prepectal carina never strongly raised; mesonotal flange and axillary tongue strong to weak; propodeum evenly rounded and almost always fully areolated, the areola wider than long to much longer than wide; tarsal claws pectinate, with three to eight teeth on the basal 0.7.

Petiole basally auriculate, short, and moderately arched; its length 1.2–1.7 times the apical width. Abdomen usually granulorugose basally and finely punctate apically, never coarsely punctate; second tergite with a basal pair of short grooves that diverge posteriorly. Subgenital plate of male flat, rounded at apex. Subgenital plate of female with central part depressed, often strongly so; sides of the depressed area more or less pinched together so that the plate resembles the bow of a boat; apex rarely deflexed as a broad lip but usually as a hooklike, mucronate point (Figs. 59, 54); third valvulae short and broad, usually geniculate; ovipositor occasionally decurved and evenly tapered (*vitticollis* group), but usually straight or curved upward (*scalaris* group), with the second valvulae sharply tapered at the distal 0.7, and the first valvulae of uniform width to the apex, which bears three or four teeth; second valvulae without apical swelling.

The ground color of the genus is black, often replaced by red in more southerly specimens. A yellow pigment is present in an almost universal pattern as follows: mouth parts, face, cheek, clypeus, scutellum, postscutellum, forelegs and parts of the other legs, venter of the abdomen, and a more or less triangular median apical spot on each tergite.

The unlaid eggs are subreniform to ovate with a short posteroventral, terminal, or subterminal stalk, which bears a small anchor. At the anterodorsal end often lies a small sagittal ridge.

Distribution

The genus is, like others of the tribe, apparently confined to the Holarctic region. It is better developed in North America than in Europe, but knowledge of the Asiatic species is almost nil. No truly Arctic species are known, though the ranges of several extend to the tree line and the Aleutian Islands. The known southern limits of the genus in North America are the coast of South Carolina and the Transitional zones of Arizona and California.

Habits

Very few observations on habits of the genus have been recorded. Most host records are in the Nematinae (Tenthredinidae). European literature gives also species of *Selandria* and *Dineura* as hosts, and a single specimen examined is said to have been reared from *Arge* sp.

Adults of most species are active in early summer. In Southern localities a second generation may occur, but proof is entirely lacking. Winter is passed inside the host cocoon.

KEY TO FEMALES OF *Eudiaborus*

1. Third valvulae simple or very slightly excavated apicoventrally; subgenital plate rounded apically, bearing a wide, reflexed lip (Figs. 25, 26, 33, 35, 37).....2
Third valvulae apicoventrally excavated; (Figs. 14, 17, 19) subgenital plate acute apically and usually bearing a hooklike mucro, but never liplike (Figs. 14, 31, 42).....4

2. Ovipositor decurved; third valvulae in lateral view tapered; body color red (Figs. 22, 26).....*pyelechus* n. sp.
Ovipositor curved upward; third valvulae in lateral view parallel-sided; body color black.....3

3. Third valvulae simple; subgenital plate merely curved below; its lip extending the full width of the abdomen (Fig. 33).....*eximius* n. sp.
Third valvulae very weakly geniculate; subgenital plate boat-shaped, its lip less than one-quarter as wide as the abdomen (Figs. 35, 36, 37).....*devius* n. sp.

4. Third valvulae excavated apicomedially or thin, spatulate, and divaricate but never geniculate (Figs. 14, 19, 32); ovipositor decurved (Figs. 15, 27).....5
Third valvulae geniculate (Figs. 17, 60); ovipositor straight or curved upward (Fig. 18)..7

5. Third valvulae thin, spatulate, and divaricate; far northern in distribution (Figs. 19, 21).....*glutiniatus* (Rmn.)
Third valvulae complexly excavated apicomedially; eastern in distribution.....6

6. Subgenital plate not mucronate; body color red (Figs. 31, 32).....*flavicircus* n. sp.
Subgenital plate mucronate; body color black (Figs. 13, 14).....*vitticollis* (Cress.)

7. Upper margin of subgenital plate strongly concave; mucro parallel-sided, truncate, about twice as long as wide; inner margins of eyes parallel; abdomen red (Figs. 41, 42, 43).....*nigrocephalus* (Davis)
Upper margin of subgenital plate straight or convex; mucro pointed; inner margins of eyes divergent below; abdomen black or red.....8

8. Ungues apically spatulate, broadened horizontally, curved through less than 45°, with five to eight teeth on the basal half (Fig. 6).....*similis* (Davis)
Ungues apically terete and sharp, curved through 60° or more, three to five teeth on the basal 0.7 (Fig. 7).....9

9. Mesonotal flange well developed, conspicuously enlarged behind the posterior margin of the tegula; axillary tongue apically porrect, free for a length at least equal to its width (Fig. 11).....11
Mesonotal flange poorly developed, of about equal height behind and at the apical margin of the tegula; axillary tongue appressed, scarcely visible from above, the free part at most wider than tall (Fig. 12).....13

10. Flagellar joints 10–20 as wide as long; eyes with broad, complete yellow orbits (Figs. 49, 50).....*luminosus* n. sp.
Flagellar joints 10–20 from 1.5–2 times as long as wide; eyes with incomplete yellow orbits.....11

11. Mesonotal flange very tall and decidedly incurved above; abdomen red..*scaphuloides* n. sp.
Mesonotal flange not tall and not at all incurved above; abdomen black.....12

12. Mucro narrow and strongly deflexed, scarcely projecting; apical margin of subgenital plate emarginate (Figs. 52, 53); third valvulae black-tipped.....*pulchellus* n. sp.
Mucro broad and porrect; apical margin of subgenital plate straight (Figs. 38, 39, 40); third valvulae yellow.....*leptonyx* n. sp.

13. Apical margin of subgenital plate usually narrowly and deeply inflexed or the mucro unusually long and straight (Figs. 59–63); third valvifer squarely truncate; inner orbits broadly yellow to the top of the eyes.....*dorsalis* (Cress.)
Apical margin of subgenital plate not at all inflexed; third valvifer obliquely tapered; inner orbits with much less yellow.....14

14. Upper and lower margins of subgenital plate in lateral view subparallel, with apical margin at right angles to both (Figs. 56, 57, 58, 17); a definite glabrous area on the mesopleuron; temple gibbous.....*promediatus* n. sp.
Upper and lower margins of subgenital plate in lateral view converging at about 30°; the lower apical angle about 120° (Figs. 54, 55); mesopleuron entirely coarsely punctate; temple flattened; body unusually hairy.....*maculiventris* (Ashm.)

KEY TO MALES OF *Eudiaborus*

1. Mesonotal flange well developed, conspicuously enlarged behind the posterior margin of the tegula; axillary tongue apically porrect, free for a length at least equal to its width (Fig. 11)..... 2
Mesonotal flange poorly developed, of about equal height behind, and at the posterior margin, of the tegula; axillary tongue appressed, scarcely visible from above, the free part at most wider than tall (Fig. 12)..... 8

2. Antennae scarcely tapered, the penultimate segment about 0.8 times as wide as the widest segment; 15th joint about as wide as long..... *pyelechus* n. sp.
Antennae more tapered, the penultimate segment about 0.6 times as wide as the widest segment; 15th joint from 1.4–2 times as long as wide..... 3

3. Tarsal claws apically blunt, spatulate, and curved through less than 45° (Fig. 6)..... *similis* (Davis)
Tarsal claws apically thin and sharp-pointed, curved through more than 60° (Fig. 7)..... 4

4. Mesonotal flange incurved above, axillary tongue as tall as the mesonotal flange; abdomen red; mesonotum usually yellow centrally..... *scaphuloides* n. sp.
Mesonotal flange not incurved above, slightly divergent; axillary tongue lower than flange..... 5

5. Abdomen red..... 6
Abdomen black..... 7

6. Inner margins of eyes subparallel; inner orbits not extending above the antennal sockets..... *nigrocephalus* (Davis)
Inner margins of eyes divergent below; orbits wide and complete..... *flavicircus* n. sp.

7. Inner orbits not extending above antennal sockets; at least upper median part of face black; western in distribution..... *leptonyx* n. sp.
Inner orbits extending, sometimes discontinuously, to the top of the eyes, where they are expanded; face yellow; eastern in distribution..... *vitticollis* (Cress.)

8. Temples flat and broad, in lateral aspect 1.5–1.7 times as wide as the eyes, closely and coarsely punctate; mesopleuron completely coarsely punctate; center of face and hind coxae black and coarsely punctate; body unusually hairy..... *maculiventris* (Ashm.)
Temples rounded, less than 1.5 times as wide as the eyes, often finely punctate; face yellow, hind coxae rarely black..... 9

9. Inner margins of the eyes subparallel; hind femora stout, only four times as long as deep; abdomen and hind legs red; mesopleuron very finely punctate..... *nigrocephalus* (Davis)
Inner margins of the eyes usually divergent below; hind femora five to six times as long as deep; abdomen black; mesopleuron more coarsely punctate..... 10

10. Inner margins of eyes subparallel; hind legs with yellow coxae, red femora, and black tibiae and tarsi..... *pulchellus* n. sp.
Inner margins of eyes divergent below; hind legs not colored as above..... 11

11. Inner orbits broadly and evenly yellow to the top of the eyes; apical margin of tergite two red..... *dorsalis* (Cress.)
Inner orbits not, or narrowly and irregularly, yellow above the antennal sockets..... 12

12. Temple 0.9–1.2 times as wide as eye in lateral view; abdomen very highly polished; petiole 1.4–1.6 times as long as wide apically, its surface shining and weakly verrucose or punctate; surface of propodeum often similar, the costulae usually weak or absent; apical sternites black, sometimes with yellow margins..... *glutiniatus* (Roman)
Temple 1.0–1.5 times as wide as eye in lateral view; abdomen not so highly polished, the basal tergites rugulose basally; petiole 1.1–1.4 times as long as wide apically, its surface usually dull and strongly rugulose; surface of propodeum often similar, the costulae usually strong; apical sternites yellow, at least medially..... *promediatus* n. sp.

Eudiaborus pyelechus n. sp.

The long, decurved ovipositor, tapered only at the apex (Fig. 22), non-excavated ovipositor valves, and narrow, evenly tapered, troughlike, subgenital plate (Figs. 25, 26) make the female unmistakable. The male may be distinguished by its unusually strongly convex metapleuron, largely red and yellow body, and well developed, reddish mesonotal flange and axillary tongue.

The antennae are black on the basal half, abruptly changing to yellow on the apical half. The joints are exceptionally short and wide, joint 15 being as wide as long and only 0.27 times as long as joint one of the flagellum. It must be borne in mind that this is based on one male only, and also that the male of *E. luminosus* may well be very similar.

This species is a member of the smaller and more primitive section of the genus, the *vitticollis* group. Within this group, however, it has no close relatives in the Nearctic region, and is considered the most primitive species.

Holotype

Female; length 6 mm.; temple 1.1 times as wide as eye, strongly gibbous below; cheek and temple coarsely but rather sparsely punctate; vertex more finely but thickly punctate; antenna unusually stout, tapered at apex only, joint 15 as broad as long.

Mesonotal flange well developed, 0.4 times as wide as tegula; axillary tongue as tall as wide; mesopleuron coarsely, and moderately thickly, punctate; metapleuron very strongly convex and coarsely punctate; propodeum short, abruptly declivate, its surface weakly verrucose, completely and strongly carinate; areola as wide as long, its basal carina present and strong; lower abscissa of nervellus 0.3 times total length; discoidella strongly pigmented.

Petiole 1.1 times as long as wide at apex, granulorugulose; tergite two rugulopunctate; remainder of abdomen finely punctate; subgenital plate narrow and troughlike, upper and lower margins converging at 30°; upper margin strongly concave basally, the lower curved upward apically to join the upper; apex rounded and bearing a shallow, transverse lip; mucro absent; third valvulae simple, not excavated, slightly tapered, rounded apically, twice as long as wide; ovipositor slender, decurved throughout its length, tapered only at tip; apex of first valvula with three or four teeth; apex of second valvula laterally expanded.

Color of head, antenna, and mesonotum black, with remainder of body red and the following parts yellow: apical 0.4 of antenna; scape below; mouth parts; clypeus; face; broad orbit encircling eye; cheek, temple, and postgena to half eye-height; propleuron; lower margin of pronotum; discal spots on mesonotum which are connected to one another and to broad vittae lying mesad of notaulices; anterior end of lateral lobe; tegula; subtegular ridge; scutellum; postscutellum; lower third of mesopleuron; mesosternum and prepectus; lateral spots on metapleuron and propodeum; fore and middle coxae and trochanters; hind coxa; hind trochanter below; apical margins of tergites one to five centrally; apical tergites laterally; venter; third valvulae ventrally. Posterior 0.2, and lateral margins, of mesonotum red. Sternaulus red.

Allotype

Male; like the female except as follows: length 5.5 mm., temple only 0.9 times as wide as eye, tergite three basally rugulopunctate.

Color is like that of the female except as follows: postocciput black, lateral lobes of mesonotum laterally and anteriorly red with no yellow, prepectus yellow only mesally, lower anterior part of mesopleuron yellow, sternaulus and mesosternum laterally dark and centrally yellow, propodeum red, yellow marking on abdomen much smaller.

Egg

Reniform and without carinae; stalk short and rising ventrally halfway between center and posterior apex (Figs. 23, 24).

Variation

Female paratypes.—Length 5.5–7 mm.; upper margin of pronotum laterally often yellow; sternaulus sometimes black; metapleuron and propodeum sometimes entirely yellow except petiolarea, or propodeum sometimes entirely red; petiole often with yellow vittae along dorsal carinae and glimmae; genitalia and subgenital plate red or yellow.

Specimens Seen (*1*♂, *5*♀♀)

Holotype.—Female, Takoma Park, Maryland, May 30, 1943, H. & M. Townes (Townes).

Allotype.—Male, Youngwood, Pennsylvania, May 26, 1941, H. K. Townes (Townes).

Paratypes.—MICH.: ♀, Midland Co., June 9, 1940, R. R. Dreisbach (Dreisbach). MASS.: ♀, South Hadley, June 7, 1936, M. Chapman (Townes). PA.: ♀, Somerset Co., June 7, 1934, J. E. Reitz (Townes). N.J.: ♀, Moorestown, June 23, 1939, H. & M. Townes (Townes).

All records are confined to the Carolinian Zone with slight overlap into the Alleghenian.

The species has been taken only in late May and June.

Eudiaborus flavicircus *n. sp.*

This species is readily recognized in the female sex by the unique form of the third valvulae (Figs. 30, 32) and the absence of a mucro (Figs. 31, 32). The male here associated is best recognized by the broad yellow orbits completely encircling the eyes and by the largely yellow head and thorax. It may be distinguished from *E. pyelechus* by the weakly convex metapleuron, and by the middle antennal joints being about 1.5 times as long as wide. The male of *E. luminosus* is unknown but most probably resembles the above two species.

This species is a member of the *vitticollis* group and is most nearly related to *E. vitticollis* (Cresson).

Holotype

Female; length 6 mm.; temple 1.2 times as wide as eye; cheek, temple, and vertex moderately punctate, but appearing smooth owing to yellow color; temple and cheek strongly gibbous below.

Mesonotal flange and axillary tongue well developed; notaulus only slightly impressed; mesopleuron densely and coarsely punctate, and with a central glabrous area extending about halfway; all propodeal carinae strong;

areola as wide as long; surface of propodeum smooth, shining, sparsely verrucate; nervellus moderately strongly pigmented; lower abscissa of nervellus 0.3 times total length.

Petiole rugose, remainder of tergites smooth; subgenital plate boat-shaped, upper margin straight to apex, lower margin converging at about 30°, then curving upward to meet upper margin at 90°; no mucro, though apex otherwise similar to that of mucronate species (Fig. 31); third valvulae strongly excavated apically, lateral and dorsal margins produced; inner ventral margin produced into a small vertical tooth (Figs. 30, 32); ovipositor thick, evenly decurved and tapered throughout its length; apex of first valvula bearing three large ventral teeth (Fig. 27).

Color of head entirely yellow except a black stripe from antennal sockets to ocelli; occiput and also postocciput behind ocelli to foramen magnum black; antenna black dorsobasally, remainder red, but ventral half of scape yellow. Thorax black, the following areas yellow: propleuron, broad upper margin laterally and broad lower margin of pronotum, on the scutum two connected discal spots joining lines on notaulices which are prolonged marginally as far back as tegulae, tegula, subtegular ridge and adjoining parts, lower 0.7 of mesopleuron except the black sternaulix and black spot before middle coxa, mesosternum, prepectus, scutellum, postscutellum, upper half of metapleuron, all coxae and trochanters. Remainder of all legs red. Propodeum black, except connected yellow areas laterally, centrally, and anteromesally. Abdomen red, with basal 0.6 of petiole black and the following areas yellow: dorsal carinae of petiole, petiolar spiracle, apical subtriangular spot on petiole, apical tergites laterally, venter and subgenital plate.

Allotype

Male; resembles the holotype except in the following details: length 5.5 mm.; temple 0.95 times as wide as eye; head and thorax very finely shagreened, but not highly polished; notaulix normally impressed; propodeal carinae stronger; surface of propodeum rugose.

Color is like that of the holotype except in the following details: antenna brown above, margins of pronotum broader, black of mesopleuron reduced to an area below subtegular ridge and a spot about mesopleural pit, metapleuron yellow, four anterior legs yellow, black of propodeum reduced to spots in petiolarea and areola, petiole yellow to red but paler basally with two short lateral black stripes, yellow apical spots on tergites one and two, venter and genitalia red.

Egg

Reniform; stalk ventral, subapical, short, twice as wide as long, being broadened in sagittal plane; foot large, oval, expanded laterally and anteriorly; small anterodorsal carina sometimes present (Figs. 28, 29).

Variation

Female paratypes.—Length 4.5–6 mm.; temple 1.1–1.2 times as wide as eye; second tergite may be rugose. Yellow is slightly less extensive in the

specimens from Ontario but much more so in the South Carolina specimen. In the latter as follows: yellow areas generally larger or broader on head and thorax, mesocoxal spot missing, black of propodeum confined to first lateral area, areola, and apex of petiolarea, broad median band on petiole, apical subtriangular spots on all tergites. Yellow on propodeum of Ontario specimen much reduced centrally to four small spots; tergites bearing small apical yellow marks.

Specimens Seen (*1* ♂, *4* ♀ ♀)

Holotype.—Female, Scioto Co., Ohio, June 9, 1945, D. J. & J. N. Knull (Townes).

Allotype.—Male, Dunes Park, Porter Co., Indiana, June 3, 1947, J. & W. Rapp (USNM).

Paratypes.—ONT.: ♀, Dacre, reared from *Pristiphora* larva on red oak under F.I.S. No. 050-554A (CNC); ♀, Orillia, June 10, 1925, C. H. Curran (CNC). S.C.: ♀, McClennanville, May 14, 1944, H. & M. Townes (Townes).

This species is apparently rather widespread in the East, having been taken in localities from the Transition to the lower Austral Zones.

Eudiaborus vitticollis (*Cresson*)

Cteniscus vitticollis Cresson, 1868, Trans. Am. Entomol. Soc. 2 : 113 (o.d., ♀, Mass.; type in ANSP).

Excavarus vitticolle Davis, 1897, Trans. Am. Entomol. Soc. 24 : 233 (key, des., Mass.).

Diaborus vitticollis Walley, 1937, Can. Entomologist, 69 : 132 (Syn.).—Brimley, 1942, Supp. Ins. North Carolina, p. 30 (Mt. Pisgah, N.C.).

The female is easily recognized by the extraordinary development of the third valvulae (Fig. 14). These are strongly excavated apically, with the sides produced posteroventrally, and in addition, the mutually adjacent margins are produced to a small point just below the dorsal apex. The male is distinct because it is the only eastern blackbodied species with strongly developed mesonotal flange. This is at least half as wide as the tegula, hyaline, and vertical. The axillary tongue is about 1.5 times as high as wide, and hyaline.

This species is one of the *vitticollis* group, is fairly closely related to *E. flavicircus*, and more distantly to *E. glutiniatus* (Roman).

Plesiotype

Female; length 6.5 mm.; temple 1.2 times as wide as eye; cheek, vertex, and temple moderately and sparsely punctate.

Mesopleuron thickly and coarsely punctate, with a large glabrous area centrally; mesonotal flange very strong, half as wide as tegula; axillary tongue hyaline, 1.5 times as tall as wide; propodeum smooth, slightly granulo-verrucate; lateral longitudinal carina weak; lower abscissa of nervellus 0.3 times total length.

Petiole rather evenly rounded posteriorly; tergite two aciculorugulose, remainder smooth, finely punctate; subgenital plate boat-shaped, upper and lower margins converging at about 35°; apical margin concave, converging on upper at about 50°; mucro exceptionally stout, rounded, and slightly decurved (Figs. 13, 14); third valvulae strongly excavated and truncate apically, outer margins produced, especially posteroventrally; inner margins of third valvulae produced to a small subdorsal, subapical point; ovipositor evenly decurved and tapered throughout its length (Fig. 15).

Color black, the following parts yellow: mouth parts, clypeus, face, cheek and temple to one-third eye-height, inner orbit to above top of eye, orbit broad at upper end, propleuron, upper and lower margins of pronotum laterally, pair of spots at anterior margin of pronotum laterally, pairs of spots at anterior margin of mesonotum just mesad of notaulices and lines extending back to a pair of discal spots, tegula, subtegular ridge, lower half of mesopleuron, mesosternum, and prepectus, but sternaulus black, scutellum, postscutellum, median apical lunate spot on each tergite, apical tergites laterally, venter except a pair of dark spots on sternite two, genitalia. Scape below and flagellum apically red. All legs and hind coxa red except the following parts yellow: all trochanters, fore and middle coxae and a ventral line on hind coxa. Hind tibia behind and apically and hind tarsus dusky.

Alloplesiotype

Male; resembles the plesiotype except in the following ways: length 7 mm.; propodeum longitudinally rugose; all carinae strong, especially apically; petiole apically irregular and rugose.

Color like that of the plesiotype except in the following details: upper part of inner orbits cut off, discal spots absent from mesonotum, mesosternum and prepectus black, lower third of mesopleuron and lateral spot on prepectus yellow, a pair of dark spots on each abdominal sternite.

Egg

Reniform-ovate; stalk very short, ventral, central; no visible anterodorsal carina (Fig. 16).

Variation

Females.—Length 6–7.5 mm.; temple 1.2–1.5 times as wide as eye; lateral longitudinal carina of propodeum may be absent. Discal spots of mesonotum often isolated from marginal marks; lower half or less of metapleuron often red.

Males.—Length 5–7 mm.; temple 1.2–1.5 times as wide as eye. Upper part of orbit may be narrowly connected below as in female; discal spots sometimes present on mesonotum. Males from Mt. Pisgah, N.C., have yellow on the mesopleuron reduced to a spot above middle coxa.

Specimens Seen (*7* ♂♂, *10* ♀♀)

Plesiotype.—Female, MacLean Reserve, Tomkins, Co., New York, May 29, 1937, H. K. Townes (Townes).

Alloplesiotype.—Male, same data as plesiotype but May 22 (Townes).

Other specimens.—SASK.: ♀, Earl Grey, July 4, 1926, J. D. Ritchie (CNC). QUE.: ♀, Nomininge, June 13, 1941, O. Peck (CNC); St. Anne's de Bellevue, August 14, 1939 (CNC). N.B.: ♂, Charlotte Co., August 11, 1950, bred from *Pristiphora* sp. on blueberry, C. W. Wood (CNC); ♂, Charlotte Co., June 19, 1953, bred from *Pristiphora bivittata* (Nort.) on blueberry, W. T. A. Neilson (CNC). N.H.: ♀, Mt. Washington, Cragway Spring at 4700 ft., August 25, 1951, H. M. & D. Townes (Townes). MASS.: ♀, no further data (Holotype) (ANSP); ♀, not localized, May 30, 1890, I. G. Jack, parasite on Spiraea sawfly (MCZ). CONN.: ♀, Cromwell, April 23, 1940, M. P. Zappe (USNM). PA.: ♀, Dupont, August 11–16, 1944, H. K. Townes (USNM); ♀, Spring Brook, May 22, 1945, H. K. Townes (Townes). N.C.: 4♂♂, ♀ Pisgah Mt., 4800-5300 ft., June 21, 1940 (Townes & USNM).

The range of this species is in the Transition and Canadian Zones with some overlap into the Carolinian. It has been reported no farther west than Saskatchewan.

The species has been reared from *Pristiphora bivittata* (Nort.) on blueberries.

Adults appear from April in the Carolinian Zone to June in the Canadian. The females apparently live till well into August.

Eudiaborus glutiniatus (*Roman*)

Diaborus glutiniatus Roman, 1909, Naturw. Unters. d. Sarekgebirges, 4 : 282 (o.d., Sweden; type in Stockholm).

This species is placed in the Nearctic fauna after comparison with a European female determined by Roman.

The unusual development of the third valvulae will at once distinguish the female (Fig. 19). The male is best identified by the very highly polished and sparsely punctate abdomen with sublinear apical yellow marks on the tergites. A distinctive character found in both sexes is the unusual length and slenderness of the tarsal claws and their combs.

This species is anomalous in several respects. The form of the ovipositor and development of the third valvulae place it as a member of the *vitticollis* group. Within the group it shows a slight affinity to *E. vitticollis* (Cresson) in the divaricate third valvulae and form of the subgenital plate.

Plesiotype

Female; length 4.5 mm.; temple as wide as eye, flattened; cheek, temple, and vertex finely punctate.

Mesonotal flange and axillary tongue poorly developed; mesopleuron coarsely, but not thickly punctate, with a small glabrous area about mesopleural pit; propodeum strongly carinate, its surface shining, rather smooth; petiolarea small, only half as long as propodeum; costulae weak and incomplete; lower abscissa of nervellus 0.15 times total length; discoidella weakly pigmented.

Petiole 1.4 times as long as apical width, dorsal carinae 0.6 times its length, surface gently rugulose; rest of tergites smooth and shining with a few sparse hairs; subgenital plate boat-shaped, upper and lower margins subparallel, apical margin meeting upper at about 60° (Fig. 21); mucro large, decurved, transversely spatulate, with a ventral rib (Fig. 20); third valvulae flattened, semiorbicular, divaricate below (Figs. 19, 21); ovipositor decurved throughout its length; second valvulae tapered most strongly near apex.

Color black, the following parts yellow: mouth parts; clypeus; face; inner orbit tapering rapidly above the antenna; scape below; cheek to one-quarter eye-height, the yellow area not attaining the occipital carina; propleuron; upper and lower margins of pronotum laterally; tegula; mesosternum and adjacent parts of prepectus; lateral spots on prepectus; scutellum apically; postscutellum; broad median apical band on each tergite; distoventral parts of tergites three and those following; venter except a pair of dark spots on sternites two to four; genitalia except the external dorsal half of third valvula. Antenna black dorsobasally, the remainder brown. Legs red except for the following areas: fore and middle coxae and trochanters, hind coxa and trochanter ventrally, hind tarsus and tibia dusky.

Alloplesiotype

Male; resembles the plesiotype except in the following details: mesopleuron less coarsely punctate, lower abscissa of nervellus 0.2 times total length, discoidella not pigmented, costula strong and complete, dorsal carinae of the petiole 0.75 times its length.

Color resembes that of the plesiotype except in the following details: only anterior half of cheek to 0.2 times eye-height yellow; propleuron, prepectus, and mesosternum black; two small apical spots on scutellum yellow; postscutellum black; middle coxa red basally; hind coxa red below and dusky above; all sternites black with yellow margins; genitalia dark brown; antenna dusky, but black dorsobasally.

Variation

Females.—Length 3.5–6 mm.; temple 1.0–1.3 times as wide as eye; mesopleuron may be densely punctate; length of petiole 1.2–1.4 times apical width. Inner orbit may be narrowly yellow to top of eye; prepectus varies from entirely yellow to black; usually a small, yellow stripe on sternaulix; subtegular ridge usually yellow; scutellum sometimes entirely black; hind coxa and trochanter sometimes dark red or black above.

Males.—Length 4–7 mm.; temple 1.0–1.3 times as wide as eye; petiole 1.4–1.6 times as long as wide apically; puncturation of mesopleuron varying from fine to coarse; costulae strong, weak, or absent; scutellar spots united or absent; hind coxa and trochanter and middle coxa, black above and yellow below in Alaskan specimens; hind femur, and middle and anterior femora behind, red to black; hind tibia and tarsus often black; middle tibia and tarsus usually dusky.

The European female determined as this species by Roman falls within the range of variation in the Alaskan series.

The female from Mt. Katahdin differs more widely from the others but does not exceed the normal range of intraspecific variation. Such characters may be of subspecific importance, but any nomenclatorial innovations should be postponed until more adequate material is available. This specimen differs from the plesiotype as follows: cheek and temple much less finely punctate; glabrous area about the mesopleural pit extending more than halfway across pleuron; surface of propodeum rugulose, costula strong; petiole 1.2 times as long as wide apically; subgenital plate similar except that the mucro is small, porrect, terete, and sharply pointed; gena and postgena yellow to 0.4 eye height; entire prepectus and lower 0.3 mesopleuron yellow, except black sternaulus; subtegular ridge yellow; sternites of abdomen all yellow; third valvulae completely black.

A single specimen, probably female, from Robson, B.C., is referred doubtfully to this species. It is too badly damaged to be positively identifiable.

Specimens Seen (*12* ♂♂, *12* ♀♀)

Plesiotype.—Female, mile 94, Haines Cut-off Road, Chilkat Pass, Yukon Territory border at 3200 ft., July 17, 1948, on Salix, W. R. M. Mason (CNC).

Alloplesiotype.—Male, same data as plesiotype (CNC).

Other specimens.—EUROPE: ♀, T. 1. p., ? August 10, 1909 (USNM). ALASKA: 2 ♂♂, ♀, Cold Bay, 163° W., August 13 and 21, 1952, W. R. M. Mason (CNC); ♀, Naknek, August 8, 1952, W. R. M. Mason (CNC); 7 ♂♂, 7 ♀♀, King Salmon, Naknek R., July 31 to August 20, 1952, W. R. M. Mason and J. B. Hartley (CNC). B.C.: 2 ♂♂, same data as plesiotype (CNC); ? ♀, Robson, September 16, 1938, H. R. Foxlee (Townes). ME.: ♀, Mt. Katahdin, Camp Kennedy, 3000 ft., August 1902 (USNM).

This species is circumpolar in the Boreal forest, becoming commoner near its northern limits. In the Palaearctic Region it occurs in what corresponds to our Hudsonian and Canadian Zones and is probably widespread in these zones in North America. The distribution suggests at least a pre-Wisconsin occurrence in North America, with an isolated remnant on Mt. Katahdin. The non-occurrence in Europe, outside Northern Scandinavia, may indicate a more recent invasion of that area.

Eudiaborus eximius *n. sp.*

The female is markedly distinct from all others in the genus in the shape of the subgenital plate. This is not at all boat-shaped, but merely convex, and bears a wide deflexed lip extending the entire width of the plate. In addition the third valvulae are not excavated, but parallel sided and apically rounded (Fig. 33). The male is unknown, but may be similar to that of some other species in the *scalaris* group.

This species is placed as an anomalous one in the *scalaris* group and in some respects is the most primitive in the genus.

Holotype

Female; length 6 mm.; temple 1.2 times as wide as eye; cheek, temple, and vertex moderately finely, and sparsely, punctate; temple and cheek gibbous below.

Mesopleuron densely and coarsely punctate, with a large central glabrous area; mesonotal flange and axillary tongue well-developed; scutellum unusually broad, flat and polished; propodeum ruguloverrucose, all carinae present and strong; areola about as wide as long and with a complete basal carina; discoidella weakly pigmented; lower abscissa of nervellus 0.2 times total length.

Petiole and tergite two irregular and rugose; tergites three and four basally rugulose, remainder shining; subgenital plate not boat-shaped, being merely convex laterally and flat longitudinally except for a small central swelling, apex broadly deflexed for nearly entire width (Fig. 33); third valvulae with sides subparallel, tapering slightly, not at all apically excavated but evenly rounded (Fig. 33); ovipositor of the *scalaris* type, curved upward.

Color black, the following parts yellow: mouth parts, clypeus, face, inner orbit to slightly above antennal socket, cheek and temple to one-quarter eye-height, scape below, propleuron, upper and lower margins of pronotum laterally, tegula, lateral spot on prepectus, mesosternum and prepectus centrally, tip of scutellum, postscutellum, apical subtriangular spots on tergites, apical tergites laterally, sternites except central dark spots, subgenital plate apically only. Antenna brown ventrally and apically. Legs red except the following yellow areas: fore coxa and trochanter; middle trochanter; middle coxa apically; hind tarsus and apical 0.3 of hind tibia dark. Third valvulae brown apico-ventrally.

Egg

Ovate-reniform; stalk short and broad and placed ventrally halfway between center and apex of egg; no sagittal ridge (Fig. 34).

Specimens Seen (*1* ♀)

Holotype.—Female, Farmingdale, New York, July 17, 1938, H. & M. Townes (Townes).

Eudiaborus devius *n. sp.*

The female may be distinguished from others with well-developed mesonotal flange by the form of the mucro and third valvulae (Figs. 35, 37). The mucro is broader than long, and almost lip-shared, although the subgenital plate is boat-shaped. The third valvulae are scarcely excavated at the apex, although the hirsute region is clearly indicated. The male is unknown, but is probably very similar to that of *Eudiaborus leptonyx* n. sp.

This species is placed as a primitive one in the *scalaris* group in a position intermediate between *E. eximius* and *E. leptonyx*.

Holotype

Female; length 8 mm.; temple 1.7 times as wide as eye; cheek, temple, and vertex moderately finely and moderately sparsely punctate; temple slightly receding, cheek swollen.

Mesopleuron densely and coarsely punctate, with no central glabrous area; mesonotal flange and axillary tongue well-developed; propodeum rugulo-verrucose, fully carinate but the carinae weak and often irregular except the apical carina which is strong; areola longer than wide; discoidella very weakly pigmented; lower abscissa of nervellus 0.3 times total length.

Petiole and base of second tergite irregular and rugulose; remainder of tergites polished and finely punctate; subgenital plate boat-shaped, upper and lower margins converging at about 60°, apical margin meeting upper at almost 90° (Fig. 36); mucro wider than long, almost lip-shaped; third valvulae scarcely geniculate, only slightly flattened apicoventrally, strongly hirsute in the flattened portion; ovipositor of the *scalaris* type, but strongly upwardly curved throughout its length (Fig. 37).

Color black, the following parts yellow: mouth parts, clypeus, face, inner orbit narrowly to top of eye, cheek and temple to one-third eye-height, scape below, propleuron, upper and lower margins of pronotum laterally, tegula, subtegular ridge, prepectus, mesosternum, tip of scutellum, postscutellum, apical tergites laterally, sternites and genitalia. Antenna reddish-brown ventrally and apically. Legs red except for following yellow areas: fore and middle coxae and trochanters, lower half of hind coxa and trochanter. Hind tarsus and tibia darkened. Third valvulae dusky apically.

Egg

Ovate-reniform; stalk apicoventral, comparatively low and broad; anchor small; sagittal ridge short and papilliform.

Variation

Female paratypes.—Length 6–8 mm.; temple 1.5–1.8 times width of eye; mucro of Colorado paratype more liplike than those of the other types; lateral yellow spots of prepectus may be detached.

Specimens Seen (*9* ♀ ♀)

Holotype.—Female, King Salmon, Naknek R., Alaska, August 3, 1952, W. R. M. Mason (CNC No. 6192).

Paratypes.—ALASKA: 3 ♀ ♀, same data as holotype but August 3 to 10, W. R. M. Mason and J. B. Hartley (CNC); ♀, Summit Lake at 3300 ft., Isabella Pass, Richardson Highway, August 1, 1951, W. R. M. Mason (CNC). MAN.: ♀, Churchill, July 21, 1937, W. J. Brown (CNC). COLO.: ♀, Poudre Lake, Rocky Mountain National Park, at 11,000 ft., August 11, 1948, Townes family (Townes). SWEDEN: ♀ bearing labels Lapponia, Boheman, Holmgren, Col. Maekl., 58 (Stockholm Museum). RUSSIA: ♀ bearing labels, Pjalitsa, Lapp. ross., J. Sahlbg., 407 (Helsinki Museum).

This species has a widespread distribution in the Hudsonian Zone of North America and also occurs in northern Europe. Mr. Kerrich has compared a

paratype of *E. devius* with a few Scandinavian specimens[4], which he had intended to describe as new, and has pronounced them to be practically identical. He has most generously decided to refrain from publishing his name to give priority to the name *devius*. I wish to thank him and the curators of the above Scandinavian museums for making possible the loan of the two European paratypes.

Eudiaborus nigrocephalus (*Davis*)

Diaborus nigrocephalus Davis, 1897, Trans. Am. Entomol. Soc. 24 : 232 (o.d. key, ♀, Ga.; type in ANSP).

Our knowledge of this rare insect is based on only three collections, one luckily being a good series of both sexes taken by the Towneses and including the only known males.

The very characteristic shape of the subgenital plate is alone sufficient to distinguish the female (Fig. 43). The male has a number of rather unusual features. The inner margins of the eyes are parallel, not divergent below; the temple, vertex, and mesopleuron are very finely and sparsely punctate; mesonotal flange and axillary tongue are moderately developed, the latter broader than tall. These features together with the red abdomen and inner orbits truncate at the antennal sockets are diagnostic.

This is a primitive member of the *scalaris* group and finds its nearest Nearctic relative in the western *E. leptonyx* and the sub-Arctic *E. devius*. With the former it shares a straight ovipositor, and with both a moderately excavated subgenital plate without a median carina and flat broad mucro that still retains a resemblance to the primitive liplike form (Figs. 41, 42).

Plesiotype

Female; temple 1.35 times as wide as eye, receding below; cheek, temple, and vertex very finely and rather sparsely punctate; inner margins of eyes subparallel or very slightly divergent below.

Mesonotal flange moderately developed, 0.3 times as wide as tegula, but axillary tongue not well-developed, only half as tall as wide; mesopleuron finely and sparsely punctate; propodeum rounded and weakly longitudinally rugulose, its carinae all weak except the apical; marginal cell of forewing short for the genus, its greatest length only 2.2 times greatest width; discoidella weakly, or not at all, pigmented; lower abscissa of nervellus 0.2 times total length.

Petiole short and broad, only 1.2 times as long as wide at apex; tergites one and two rugulose, remaining tergites shining and very finely punctate; subgenital plate shallowly boat-shaped, without apical carina; upper and lower margins converging strongly in basal half, subparallel apically, lower curving up to mucro (Fig. 43); mucro thin and broad, about as long as its truncate apex (Figs. 41, 42); ovipositor of *scalaris* type, but straight; third valvulae strongly geniculate.

[4] *Some of these specimens were mentioned by Roman (2) when he referred to some examples of E. lituratorius (Thom. not L.) as having "einfache Bohrerscheide ohne Glutinien".*

Color of head black with rest of body red except for the following yellow areas; mouth parts, clypeus, scape and pedical below, face, inner orbit not extending above antennal socket, cheek and temple to 0.3 eye-height, lower parts of propleuron, upper and lower margins of pronotum laterally, tegula, subtegular ridge, scutellum, postscutellum, fore and most of middle coxae, all trochanters, apical margins of tergites centrally, subgenital plate and lateral corners of apical tergites. Antenna red, black dorsobasally.

Alloplesiotype

Male; like the plesiotype with the following exceptions: temple 1.25 times as wide as eye, propodeal carinae stronger, discoidella pigmented, petiole 1.35 times as long as wide at apex, hind femur broad for the genus, only four times as long as deep.

Color like that of plesiotype with the following exceptions: cheek yellow only to bottom of eye; thorax black, not red; base of notaulix dark red; lateral yellow spot on prepectus; propleuron black; basal 0.7 and lateral margins of petiole black, remainder of petiole red; apical yellow spots on tergites missing; genitalia red.

Egg

Ovate, with a short apical stalk directed ventrally; anchor large; no anterior sagittal carina.

Variation

Females.—Propleuron may sometimes be entirely red.

Males.—Mesonotum may sometimes be entirely black; basal 0.5–0.7 petiole black.

Specimens Seen (9 ♂♂, 15 ♀♀)

Plesiotype.—Female, Takoma Park, Maryland, May 7, 1943, H. & M. Townes (Townes).

Alloplesiotype.—Male, same data as plesiotype (Townes).

Other specimens.—MD.: 8 ♂♂, 12 ♀♀, same data as plesiotype, but May 6 and 7 (Townes, Swift, USNM, CNC). CONN.: ♀, South Meriden, May 21, 1939, H. L. Johnson (USNM). GA.: ♀, no further data (Type) (ANSP).

All specimens known are of Carolinian Zone origin.

Eudiaborus leptonyx n. sp.

Easily distinguished from *E. similis* (Davis) by the narrow pointed tarsal claws (Fig. 7); and from all other western species by the well-developed mesonotal flange and axillary tongue. The broad flat mucro of the female and centrally black face of the male are further distinctions.

The species is a primitive member of the *scalaris* group and may be the western analogue of *E. nigrocephalus* (Davis). With this species it shares a straight ovipositor, moderately excavated subgenital plate, and broad flat mucro still retaining some resemblance to the primitive liplike form (Figs.

38, 40). Another primitive character is the form of the third valvulae, which are geniculate, although not definitely excavated apicoventrally.

Holotype

Female; length 6 mm.; temple 1.3 times as wide as eye; vertex and temple moderately punctate; cheek coarsely and sparsely punctate.

Mesonotal flange and axillary tongue well-developed; mesopleuron densely, but not coarsely, punctate with a large central speculum; propodeal carinae strong; the apical one especially so, and subtended by transverse rugosities; lower abscissa of nervellus 0.35 times total length; discoidella very weakly pigmented.

Petiole irregular and rugose; tergite two rugose, remainder smooth, polished; subgenital plate boat-shaped, upper and lower margins converging at about 40°; apical margin short, at right angles to upper (Fig. 39); mucro small and flat, broader than long (Figs. 38, 49); third valvulae somewhat geniculate, but not excavated below.

Color black, the following parts yellow: mouth parts, clypeus, face, small spot on inner orbit at top of eye, scape below, cheek and temple to one-third eye-height, lower third of propleuron, upper and lower margins of pronotum laterally, tegula, subtegular ridge, scutellum, postscutellum, mesosternum centrally, apical lunate spot on each tergite, apical tergites laterally, venter and genitalia. Antenna red apically and centrally below. Legs red except for the following yellow areas: fore coxa; four anterior trochanters; middle and hind coxae ventrally; hind tarsus, apical 0.4, and subbasal annulus of hind tibia dark.

Allotype

Male; resembling the holotype except that the propodeum is more strongly rugose and carinate.

Color like that of the holotype with the following exceptions: face bearing a subtriangular black mark with apex at clypeus; no yellow on inner orbit; cheek and temple yellow only on anterior half, to one-quarter eye-height; propleuron, mesosternum, and all but tip of scutellum black; hind coxa entirely red; apical spots on tergites much reduced; genitalia black; antenna black except apicoventral brown area.

Egg

Reniform-ovate, with short, ventral, subapical stalk; poorly indicated apicodorsal sagittal carina.

Variation

Female paratypes.—Length 5–7 mm.; temple 1.0–1.5 times as wide as eye; central abscissa of lateral longitudinal carina of propodeum often weak or absent; tergite two sometimes rugose only basally; third valvulae often weakly excavated below; inner orbital spot usually absent; inner orbit sometimes extending slightly above antenna; yellow of temple often not attaining hypostomal carina; mesosternum sometimes entirely yellow;

occasional lateral yellow spots on prepectus; middle coxa sometimes entirely yellow; hind coxa sometimes entirely red; dark areas on hind tarsus sometimes reduced.

Male paratypes.—Length 4.5–6.5 mm.; temple 1.0–1.4 times as wide as eye; propodeal carinae varying as in female; lower abscissa of nervellus 0.2–0.4 times total length. Black on face covering all but lower corners or reduced to a T-shaped mark whose narrow stem just fails to reach clypeus; yellow of cheek and temple reduced in darkest forms to malar space only; scutellum often more than half yellow; all coxae red in some southern specimens; yellow of abdomen as extensive as that of female or reduced to almost nothing.

Specimens Seen (*40* ♂♂, *60* ♀♀)

Holotype.—Female; Norman Wells, Northwest Territories, August 3, 1949, W. R. M. Mason, swept from Salix (CNC No. 6193).

Allotype.—Male; same data as holotype, but July 7 (CNC).

Paratypes.—ALASKA: 3 ♂♂, 7 ♀♀, Naknek, July 18–August 9, 1952, W. R. M. Mason & J. B. Hartley (CNC); 21 ♂♂, 33 ♀♀, King Salmon, Naknek R., July 19 to August 23, 1952, W. R. M. Mason & J. B. Hartley (CNC); ♂, 2 ♀♀, Big Delta, June 24 to July 3, 1951, W. R. M. Mason (CNC). YUKON: ♀, Dry Creek, 62° 14′ N., 140° 40′ W., July 25, 1948, W. R. M. Mason (CNC). N.W.T.: 4 ♂♂, 2 ♀♀, same data as holotype, but July 2–26 (CNC); ♀, Yellowknife, August 17, 1949, R. R. Hall (CNC). B.C.: ♀, Robson, August 30, 1938, H. R. Foxlee (CNC). ALTA.: ♀, Blackfoot Hills, near Wainwright, August 7, 1940, A. R. Brooks (CNC); ♀, Edmonton, August 6, 1938, W. R. M. Mason (CNC); ♀, Lethbridge, July 6, 1929 (Townes); ♂, Slave Lake, August 14, 1924, O. Bryant (USNM). WASH.: ♂, Mt. Rainier at 4200 ft., July 15, 1940, H. & M. Townes (Townes). COLO.: ♂, Big Muddy Creek, 10 mi. NW of Kremling at 7500 ft., August 17, 1948, H. E. Evans (CNC); ♂, Grant, Geneva Pk. at 10,000 ft., July 21, I. O. Jackson (PRR); ♀, Hayden, August 23, 1940, H. & M. Townes (Townes). CALIF.: ♀, Donner Pass, 7100 ft., August 1, 1948, Townes fam. (Townes); ♀, Fish Camp, July 15, 1948, Townes fam. (Townes); ♂, Crane Flat, Yosemite Park, July 12, 1948, Townes fam. (Townes); ♂, 2 ♀♀, near Glacier Point, Yosemite Park, July 17–20, 1948, Townes fam. (Townes); ♂, ♀, Snow Flat, Yosemite Park, 8700 ft., July 27, 1948, Townes fam. (Townes). ARIZ.: 3 ♂♂, ♀, Oak Creek Canyon, May 18–21, 1947, H. & M. Townes (Townes). MAN.: ♀, Gillam, July 13, 1950, J. F. McAlpine (CNC). NFLD.: ♀, Goose Bay, Labrador, August 3, 1951, D. L. Watson (CNC).

This species ranges from the Hudsonian to the Transition Zone in the West. It occurs as a rarity in the Hudsonian Zone as far east as Labrador.

A late season peak of adult activity is indicated by the captures, which were nearly all made after the middle of July. The June records from Alaska were taken in an exceptionally early summer.

Eudiaborus luminosus *n. sp.*

This is distinguished from all other members of the *scalaris* group by having the middle joints of the antenna about as long as wide. The red color, shape of the subgenital plate (Fig. 50), strong nervellus, and well-developed mesonotal flange are additional characters. The male is unknown.

This is another primitive and isolated member of the *scalaris* group.

Holotype

Female; length 7 mm.; temple 1.2 times as wide as eye, gibbous, especially strongly so below; vertex, temple, and cheek moderately and densely punctate; antenna tapered little except at tip, 15th joint as wide as long.

Mesopleuron coarsely and densely punctate with a glabrous central area extending about halfway; mesonotal flange and axillary tongue well-developed; propodeum very short and abruptly declivate; areola as wide as long, its basal carina strong; lateral longitudinal carina weak, surface of propodeum rugulose; lower abscissa of nervellus 0.3 times total length; discoidella as strong as other hind wing veins.

Petiole and second tergite basally rugulose, remainder smooth and shining; subgenital plate boat-shaped, narrow, upper and lower margins converging at about 30°; apical margin concave, converging toward upper at about 80° (Fig. 50); mucro declined, terete, pointed (Fig. 49); third valvulae geniculate; ovipositor of the *scalaris* type.

Color of head yellow, with a median black band from antennal sockets to ocelli; vertex, occiput, and postocciput down to foramen magnum black. Antenna black, apical half, and scape ventrally yellow. Thorax black, the following areas yellow: propleuron, broad lower margin and broad upper lateral margins of pronotum, two large connected discal spots on mesonotum, broad lines along notaulices continued laterally to tegula, tegula, subtegular ridge and adjoining area, prepectus, mesosternum, lower 0.75 of mesopleuron leaving black spots on sternaulix and above middle coxa, scutellum, post-scutellum. Metapleuron and propodeum reddish yellow. All coxae and trochanters and four anterior legs yellow. Hind legs red. Abdomen red, the following parts yellow: large lunate apical spot on each tergite, apical tergites laterally, venter partly, subgenital plate.

Egg

Reniform; stalk of moderate length, ventral, subapical; apicodorsal sagittal carina present and well-marked.

Specimens Seen (*1* ♀)

Holotype.—Female; Ithaca, New York, June 12, 1935, P. P. Babiy (Townes).

Eudiaborus scaphuloides *n. sp.*

Diaborus ornatus (Walsh), Proctor, 1946, Biol. Survey Mt. Desert Region (misdet. in part, Me.).

This species is easily mistaken for a *Cteniscus* but may readily be distinguished by the key characters. The outstanding feature is the very strong

development of the mesonotal flange which is almost as wide as the tegula and extends as a vertical, slightly incurving plate to about the anterior tip of the tegula. The female is further characterized by possessing incrassate hind tibiae which are wider than their femora. The female genitalia are, as with most species of this genus, quite distinctive in themselves when studied carefully (Figs. 44, 45).

Beyond placing this species in the *scalaris* group it is hard to make any further statement about its affinities.

Holotype

Female; length 6 mm.; temple 1.4 times as wide as eyes; gibbous below; temple, cheek, and vertex smooth, polished, and finely punctate; antenna rather long and thin for the genus.

Mesonotal flange large and hyaline, as wide as tegula and extending forward to middle of tegula; axillary tongue prominent, taller than wide and densely pigmented; mesopleuron shining, finely punctate, with large central glabrous area; propodeum smooth, somewhat papillate, carinae all present and all weak except apical and median carinae of petiolarea; hind coxa impunctate; hind tibia incrassate, broader than femur and widest at 0.7 of their length from base; lower abscissa of nervellus 0.5 times total length; discoidella pigmented.

Petiole and base of tergite two rugulose, remainder of tergites smooth and shining; subgenital plate boat-shaped, upper and lower margins converging at 20°; apical margin at 90° to upper (Fig. 45); mucro one-third as long as apical margin, straight, pointed, and declined 30° from upper margin (Fig. 44); ovipositor of *scalaris* type, but straight; valvulae geniculate.

Color of head and thorax black, the following parts yellow: mouth parts; clypeus; face; inner orbit broadly to top of eye and nearly touching lateral ocellus; cheek, temple, and postgena to 0.7 eye-height and to foramen magnum; scape ventrally; propleuron; upper margin laterally, and lower margin, of pronotum; mesosternum; prepectus, except black spots immediately behind forecoxae; tegula; subtegular ridge; a large central spot on mesonotum; scutellum; postscutellum. Antenna black basally, reddish apically. All legs red with yellow coxae and trochanters; hind tibia divided longitudinally into anterior red and posterior fuscous halves. Abdomen red with black petiole and the following areas yellow: midapical lunate spot on each tergite, apical tergites laterally, venter, subgenital plate. The following parts of abdomen black: base of tergite two; pair of central spots on anterior tergites; tergites two, three, and four laterally.

Allotype

Male; resembling the holotype except in the following details: temple as wide as eye and less gibbous below; propodeum more rugulose and with stronger carinae; hind tibia of normal size, narrower than femur and widest at apex; petiole weakly tapered and narrow for the genus, being 1.5 times as long as wide apically and only 1.4 times as wide apically as basally.

Color like that of the holotype with the following exceptions: postgena black; propleuron black dorsally; mesosternum and prepectus black except small lateral yellow spots on latter; midapical spots of tergites ill-defined and small; lateral black margins large and merging with central spots to form triangles on tergites two, three, and four; tergites five and six dark reddish but paler medially; genitalia reddish.

Egg

Reniform-ovate; stalk ventral, subapical; a very low and inconspicuous sagittal flange anterodorsally.

Variation

Female paratypes.—Length 5.5–6.5 mm.; temple 1.0–1.35 times as wide as eye. Dark markings on tergites sometimes paler and smaller than those of type, and yellow midapical spots sometimes poorly defined and almost disappearing, or increasing to about half size of tergite.

Male paratypes.—Length 4.5–7.5 mm.; temple 1.0–1.2 times as wide as eye; petiole 1.3–1.65 times as long as wide at apex, which is 1.3–1.45 times as wide as base. Specimen from Apponaug, R.I., with a yellow band on the lower part of the mesopleuron; specimens from Maine and Quebec without midapical yellow abdominal spots except on the first tergite and with abdominal dark markings of greater extent. Specimens from Apponaug, R.I., and Mt. Moscow, Ida., with almost entirely red abdominal tergum behind the petiole. Yellow central mesonotal spot sometimes much reduced.

Specimens Seen (*9* ♂♂, *10* ♀♀)

Holotype.—Female; Randolph, New Hampshire, July 3, 1946, J. Peck & M. Townes (Townes).

Allotype.—Male; same data as holotype but July 5 (Townes).

Paratypes.—IDA.: ♂, Moscow Mt., July 7, 1918, A. L. Melander (MCZ). MICH.: ♀, Twin Lakes, Houghton Co., July 20–22, 1937, H. H. Ross (Ill.). ONT.: ♀, Constance Bay, August 15, 1944, G. S. Walley (CNC). QUE.: ♂, Gracefield, June 23, 1937, O. Peck (CNC); ♀, Meach Lake, July 9, 1941, G. A. Hobbs (CU); ♂, Stoneham, June 18, 1938, H. & M. Townes (Townes). ME.: ♂, Bar Harbour, August 18, 1920 (USNM); ♂, Liberty, September 13, 1913, C. W. Johnson (MCZ); 2 ♀♀, Pittston, August 3, 1890 (MCZ). N.H.: ♀, Mt. Washington, Dolly Copp, July 4, 1936, A. L. Melander (MCZ); ♂, Mt. Madison, June 24, 1938, H. & M. Townes (Townes); ♂, 2 ♀♀, same data as holotype but July 3–5 (Townes). R.I.: ♂, Apponaug, June 26, 1912 (MCZ). MD.: ♀, Patuxent Research Refuge, Bowie, October 7, 1946, R. T. Mitchell (Mitchell).

The distribution is chiefly in the Transition Zone and may be transcontinental. It also overlaps into the Carolinian and Canadian Zone.

In the Transition Zone adults are active in late June and July, but males taken during late August and September in Maine indicate a possible second generation.

Eudiaborus similis (*Davis*)

This species is believed to be decidedly polytypic and four subspecies are recognized.

The typical subspecies occurs in the Rocky Mountains and Coast Ranges as far north as British Columbia; another occurs in the Canadian Zone east of the Rockies; a third in the coast ranges from the Puget Sound area to the Aleutians; and a fourth is known only from Nebraska.

The species is distinguished from all other *Eudiaborus* known to the author by the structure of the tarsal claws. These are transversely spatulate at the tip, curved through only about 45°, and bear four to eight teeth on the basal 0.5 (Fig. 6). All other species of the genus have terete, pointed claws which are curved through about 90° and bear three to six teeth on the basal 0.7 (Fig. 7).

The position of this species is a fairly primitive one in the *scalaris* group but apparently near the main line of development.

Eudiaborus similis similis (*Davis*)

Diaborus similis Davis, 1897, Trans. Am. Entomol. Soc. 24 : 231 (o.d., ♀, Colorado, key, Mont.; type in ANSP).

The range of this subspecies probably touches the range of all others. It is distinguished from *E. s. nebraskensis* (Davis) by the far smaller extent of yellow, from *hilaretinctus* by the black abdomen with large lunate apical yellow spots on the tergites. The centrally black face and black hind femora distinguishes the male from *citrifrons* while the female is distinguished by the extensive red areas on the hind coxa. I have seen many specimens showing intermediate coloring between the last two subspecies from the higher altitudes of the Cascade Mountains of Washington and southern British Columbia.

Plesiotype

Female; length 7.5 mm.; temple 1.35 times as wide as eye; cheek, temple, and vertex moderately densely, but not coarsely, punctate; cheek gibbous below.

Mesonotal flange and axillary tongue well-developed; mesopleuron coarsely and thickly punctate except large central speculum; metapleuron shiny, carina incomplete; propodeum rugulose, carinae weak except the apical, which is strong and raised laterally; lateral longitudinal carina absent; tarsal claws transversely broadened and flattened apically, curved through only about 45°, four to eight teeth on basal 0.5 (Fig. 6); discoidella well pigmented; lower abscissa of nervellus 0.3 times total length.

Tergites one and two rugose, three and four rugulose basally, remainder shiny; subgenital plate boat-shaped, upper and lower margins converging at about 35°; apical margin straight and at 90° to upper (Fig. 48); mucro broad and flat, rounded apically, slightly decurved; third valvulae geniculate; ovipositor of *scalaris* type.

Color black, the following areas yellow: mouth parts; clypeus; face; scape below; inner orbit narrowly to top of eye; cheek and temple to one-third eye-height; upper margin, and lower margin of pronotum laterally; propleuron; tegula; subtegular ridge; scutellum; postscutellum; mesosternum narrowly behind, broadly in front, and adjoining parts of prepectus; lateral spot on prepectus; large lunate spots on tergites; apical tergites laterally; venter; genitalia. Antenna apically brown below. All legs red except for the following yellow parts: all trochanters, fore and middle coxae, ventral third and dorsal stripe on hind coxa. Hind coxa black basally, red laterally; hind trochanter black above; hind tarsus and upper half hind tibia dusky.

Alloplesiotype

Male; like the plesiotype with the following exceptions: length 6.5 mm., temple 1.4 times as wide as eye, temple and vertex more coarsely punctate, temple less gibbous below, propodeum completely strongly carinate except weak lateral longitudinal carina, lower abscissa of nervellus 0.4 times total length.

Color similar to that of the type except as follows: triangular black area on face with base at antennal sockets and apex near clypeus; yellow of cheek not reaching occipital carina; propleuron, prepectus, and mesopleuron black; only apical half scutellum yellow; middle coxa black basally; hind coxa black except ventral yellow line; antenna black but dusky apically.

Egg

Ovate; stalk short, ventral, subapical; anchor projecting caudally only; conspicuous anterodorsal sagittal flange.

Variation

Females.—Length 5–8 mm.; temple 1.3–1.6 times as wide as eye; temple, cheek, and vertex coarsely, to rather finely, punctate, punctures the finest in smallest specimens; lateral longitudinal carina of propodeum often present, though weak; longitudinal carinae of areola sometimes irregular or absent; nervellus strongly to weakly pigmented. Hind coxa rarely with a dorsal stripe except in Rocky Mountains specimens; basal black markings occasionally absent (Pacific Coast), or completely covering entire coxa. Occasionally two discal yellow spots on tergite two; hind tibia sometimes red with pale brown tarsus; hind femur sometimes black.

Males.—Length 5.5–8 mm.; temple 1.4–1.5 times as wide as eye; lateral longitudinal carina of propodeum sometimes absent; nervellus weakly to well pigmented. Black facial triangle varies from half length of face to most of face, meeting clypeus broadly; upper end of inner orbit often cut off; yellow of hind coxa varies from a ventral line only, to that plus apical 0.3 and dorsal surface; in some specimens from the Pacific Coast of the U.S.A. red largely replaces black in hind coxa.

Specimens Seen (*16* ♂♂, *20* ♀♀)

Plesiotype.—Female; near Estes Park, Colorado, June 14, 1948, Townes fam. (Townes).

Alloplesiotype.—Male; same data as the plesiotype.

Other specimens.—ALTA.: Laggan. B.C.: Robson; Merrit. WASH.: Westport; Big Four [Snohomish Co.]; Mt. Rainier at 4200 and 5300 ft. MONT.: a paratype not localized. ORE.: Cannon Beach. CALIF.: Crescent City; near Sonora Pass at 8000 ft.; near Glacier Point in Yosemite Park; Graegle. WYO.: Yellowstone Park. COLO.: Boulder; near Estes Park; Denver; Grizzly Creek in Larrimer Co.; Phantom Valley at 9400 ft. and Poudre Lake at 11,000 ft. in Rocky Mountain National Park; Steamboat Springs; Manitou; and some, including the holotype, not further localized.

This subspecies occurs in the Humid Transition, Canadian, and Hudsonian Zones probably throughout the Western Mountains but the northern limits of its occurrence are uncertain. At higher altitudes in the Puget Sound area it intergrades with the Alaskan Race, but little is known of its range in interior British Columbia.

Specimens have been taken from May to late August.

Eudiaborus similis hilaretinctus *n. subsp.*

Diaborus ornatus (Walsh) Davis, 1897, Trans. Am. Entomol. Soc. 24 : 232 (N.H., misdet.); Criddle, 1928, Ann. Rept. Entomol. Soc. Ontario, 58 : 102 (Alta., misdet.).

Cteniscus ornatus (Walsh) Strickland, 1946, Can. Entomologist, 75 : 40 (Alta., misdet.).

Davis took this subspecies to be *Exenteron ornatus* Walsh and other authors have followed him. Since Walsh's type is destroyed the true identity of his species can never be known, but upon examination of the specimens published upon by Davis one can safely say that they are far from fitting Walsh's description. The identity of *E. ornatus* Walsh is discussed under *Acrotomus ornatus* (Walsh).

This is the Eastern race of the species and may readily be distinguished from the other races by the development of red on the abdomen. An occasional male has been taken in which the abdomen is almost wholly black, but these are distinct because of the much smaller development of the yellow areas, particularly of the abdomen, than in the other subspecies. It is reasonable to expect a zone of intergradation between this and *E. s. similis* (Davis) in western Alberta, for a male of intermediate nature has been taken at Bilby, Alta. Intergradation with *E. s. nebraskensis* (Davis) is discussed below.

Holotype

Female; length 8 mm.; temple, vertex, and cheek moderately punctate, gibbous below; temple 1.7 times as wide as eye.

Mesonotal flange an axillary tongue well-developed; mesopleuron coarsely punctate with a small glabrous area about mesopleural pit; metapleuron

shiny, its horizontal carina weak centrally; propodeum rugulose, longitudinally aciculate laterally, its carinae strong, the apical very strong and raised laterally, lateral longitudinal carina missing; tarsal claws transversely spatulate, apically curved through about 45°, four to six teeth on basal 0.5 (Fig. 6); discoidella weakly pigmented; lower abscissa of nervellus 0.3 times total length.

Tergites one and two rugose, three and four rugulose basally, remainder coarsely punctate; subgenital plate boat-shaped, upper and lower margins converging at about 35°; apical margin straight and meeting upper at 90°; mucro flat, broadly apically rounded and slightly decurved; ovipositor of *scalaris* type; third valvulae geniculate.

Color of head and thorax black with the following areas yellow: mouth parts; clypeus; scape below; face; inner orbit narrowly above antenna but broadened at top of eye; temple, cheek, and postgena to one-third eye-height; upper and lower margins of pronotum laterally; propleuron; tegula; subtegular ridge; mesosternum except spot before middle coxa; prepectus except spot behind forecoxa; scutellum; postscutellum. Antenna black dorsobasally, remainder brown. All legs red except the following yellow parts: all trochanters, fore and middle coxae, ventral stripe on hind coxa. Hind tarsus dusky. Abdomen red with the following parts black; petiole, paired discal spots and sublateral marks on tergites two to four, tergite five black basally and laterally, remainder of tergites black. The following parts of the abdomen yellow: mid-apical lunate mark on each tergite, apical tergites laterally, venter, and genitalia.

Allotype

Male; like the holotype with the following exceptions: temple 1.45 times as wide as eye, cheek and temple strongly gibbous, temple and vertex more coarsely punctate, metapleural carina complete, propodeal lateral longitudinal carina present, petiole and tergite two basally rugulose, remainder of abdomen densely punctate.

Color resembling that of the holotype with the following exceptions: on face a black triangle with base on antennal sockets and apex near clypeus; yellow of temple extending only halfway to occipital carina; propleuron, mesosternum, and prepectus black; only apical 0.5 of scutellum yellow; tergite two black basally; no discal black spots on tergites.

Egg

Ovate; stalk short, ventral, subapical; strong anterior sagittal flange.

Variation

Female paratypes.—Length 6–8 mm.; temple 1.45–1.7 times as wide as eye; propodeal lateral longitudinal carina sometimes present as stronger aciculations. The relative extent of black and red on the abdomen ranges from almost completely red (Regina, Sask., and Tower City, N.D.) to a very extensive development of black from three centers of pigmentation. These are the lateral margins mesad of the yellow border, the basal margin, and a pair

of discal spots. The black is most strongly developed at the abdominal apex and least on tergite three. The extreme observed (Mt. Washington, N.H., alpine zone) has the tergites behind four all black and that color dominant on all other tergites with the discal red spots distinct only on tergite three. This red to black variation seems to have little effect on the extent of yellow. Lateral yellow spots on prepectus often detached.

Male paratypes.—Length 5–8 mm.; temple 1.2–1.7 times as wide as eye; strength of propodeal carinae varies. Color of the abdomen ranges from almost entirely red (Tower City, N.D.) to almost entirely black (Brome, Que., and Mt. Katahdin, Me.) with the same methods of color substitution as discussed under the female. Even in the blackest specimens the second and third tergites retain apical margins of red. The extent of the median apical yellow spots on the tergites decreases sharply with increase in the black area, so that in the darkest specimens they almost disappear. Imperfectly correlated with this is a tendency toward entirely black hind coxa and an abscission of the top part of the yellow inner orbit.

One male from Wabamun, Alta., has a yellow face and the hind coxa yellow except for laterobasal red areas. It may be regarded as showing characters of the subspecies *citrifrons* (Ashm.). A male from Bilby, Alta., has the typical pattern of the typical subspecies with the addition of a small red area on the abdomen. This is probably indicative of the influence of the Rocky Mountain race.

A female from Tower City, N.D., appears to be a transitional form between this subspecies and *nebraskensis*. The coloring is that of typical *hilaretinctus* with the following extra extensions of yellow: inner orbits broadly extending almost to lateral ocellus, temple to above middle of eye, prepectus, mesosternum, lower half mesopleuron except sternaulus, two discal and four lateral spots on mesonotum, scutellum completely, metapleural spot, petiole with yellow vittae along dorsal carinae.

Specimens Seen (*18* ♂♂, *17* ♀♀)

Holotype.—Female; Prince Albert National Park, Saskatchewan, July 20, 1941, J. G. Rempel (Townes).

Allotype.—Male; same data except July 21 (Townes).

Paratypes.—N.W.T.: ♀, Yellowknife, August 6, 1949, E. F. Cashman (CNC). ALTA.: ♂, ♀, Slave Lake, August 14, 15, 1924, O. Bryant (CNC & USNM); ♂, 2 ♀♀, Bilby [27 mi. N.W. Edmonton], July 20, 1924, O. Bryant (CNC); 2 ♂♂, 2 ♀♀, Edmonton [♂♂, June 25–27, 1945; ♀♀, August 16, 1945, and September 3, 1936], E. H. Strickland (Alta.); ♂, Morrin, June 15, 1928, G. F. Manson (CNC). SASK.: ♂, 3 ♀♀, same data as type except July 20–25 (Townes); ♀, Snowden, July 13, 1944, O. Peck (CNC); ♂, ♀, Saskatoon, September 7, 1940, and June 11, 1950, A. R. Brooks (CNC); ♀, Regina, August 8, 1941, J. G. Rempel (Townes). N.D.: ♂, Tower City, June 19, 1906, G. I. Reeves (USNM). ONT.: ♂, Macdiarmid, L. Nipigon, July 11, 1923, N. K. Bigelow (CNC); ♂, Waubamic, June 4, 1915, H. S. Parrish (CU). QUE.: ♂, Brome, June 8, 1936, G. S. Walley (CNC); ♂,

Joliette, July 19 (CU); ♂, Mt. Lyall at 1500 ft. (Gaspé Pen.), August 9, 1933, W. J. Brown (CNC). N.H.: 2 ♂♂, 2 ♀♀, no further data (ANSP); 2 ♂♂, ♀, Glen to Halfway House, White Mts., August 8, 1891 (USNM); ♂, 2 ♀♀, Mt. Washington, Tuckerman's Ravine, 5100 ft., August 24–25, 1951, H. & D. Townes (Townes); ♀, same data but Lakes of the Clouds, August 26 (Townes); ♀, Mt. Washington, Alpine Gardens, July 11, 1931, A. L. Melander (MCZ); ME.: ♂, Camp Kennedy, 3000 ft., Mt. Katahdin, August 1903 (USNM).

Specimens not included in the type series: ♀, Tower City, N.D., Grass, Webster No. 3047, June 10, 1905, G. I. Reeves (USNM) showing characters transitional to *nebraskensis*; ♂, Wabamun, Alta., August 2, 1929, E. H. Strickland (Townes) showing characters transitional to *citrifrons*; ♀, Bilby, Alta., June 15, 1924, O. Bryant (USNM) showing characters transitional to *similis*.

The subspecies occurs in the Canadian and Transitional Zones and rarely in the Hudsonian across the continent east of the Rockies. The northwestern limits are unknown.

It is taken in June and early July in the Transition Zone and about six weeks later in the Canadian Zone.

Eudiaborus similis citrifrons (*Ashmead*)

Diaborus citrifrons Ashmead, 1902, Proc. Wash. Acad. Sci. 4 : 212 (o.d., ♂, Popoff I., Alaska; type in USNM).

Ashmead's type is a typical specimen of *E. similis* (Davis) with only one striking difference, that of the face color. With present material they appear to be subspecifically distinguishable.

Both sexes resemble closely the typical subspecies. Males of *citrifrons* have black hind femora, or at least only the apicoventral half dark red, and the hind coxa with no red color and usually extensively yellow. The color of the face is unreliable. Males of *similis* have red hind femora, or at most the base dark red, and hind coxae often more or less red with smaller yellow areas. The females have much more extensive yellow areas in the hind coxae and only occasionally red areas, whereas *similis* females usually have very extensive red areas and less yellow or black on the hind coxae. I have seen a number of specimens showing various degrees of coloration between this and *E. s. similis* (Davis) from higher altitudes of the Cascade Mountains in Washington and from southern British Columbia.

Plesiotype

Female; differing from the plesiotype of the typical subspecies in the following details: temple 1.5 times as wide as eye, abdomen less rugose, hind coxa yellow except the laterobasal halves.

Alloplesiotype

Male; differing from the plesiotype of *citrifrons* as follows: temple 1.3 times as wide as eye, less gibbous below; propodeum much more strongly carinate and more rugose.

Color differing from that of the plesiotype of *citrifrons* as follows: face bearing a black triangle with base at antennal sockets and apex halfway between them and the frontoclypeal suture; yellow of cheek not attaining occipital carina; propleuron, mesosternum, and prepectus black; apical half of scutellum yellow; dorsobasal half of hind femur black, apicoventral half dark red; antenna black.

Variation

Females.—Length 5–9 mm.; extent of yellow on hind coxa varying from apicoventral stripe only to entire coxa except black laterobasal quarter; occasionally (4 out of 20) small red areas present above or laterally.

Males.—Length 4.5–9 mm.; black triangle varying from 0.2–0.8 times length of face; hind femur usually black, only occasionally (3 out of 16) as in the alloplesiotype; extent of black on hind coxa varying from laterobasal third to entire coxa except the apex above.

A female from Carcross, Yukon Territory, differs from the description above in having the laterobasal spots on the hind coxa red and about half as long as coxa. It is referred to this subspecies with some doubt.

Specimens Seen (*19* ♂♂, *25* ♀♀)

Plesiotype.—Female; King Salmon, Naknek River, Alaska, August 10, 1952, W. R. M. Mason (CNC).

Alloplesiotype.—Male; same data as plesiotype but August 9 (CNC).

Other specimens.—ALASKA: ♂, Big Delta, July 3, 1951, W. R. M. Mason (CNC); ♂, Fairbanks, June 25, 1952, W. R. M. Mason (CNC); ♀, Mile 250, Richardson Highway, July 27, 1951, W. R. M. Mason (CNC); ♂, Cold Bay, 163° W., July 28, 1952, W. R. M. Mason (CNC); 5 ♂♂, 7 ♀♀, Naknek, August 8–9, 1952, W. R. M. Mason and J. B. Hartley (CNC); 9 ♂♂, 13 ♀♀, King Salmon, Naknek R., July 19 to August 16, 1952, W. R. M. Mason and J. B. Hartley (CNC); ♂, Popoff I., Harriman Exped. (holotype) (USNM); ♀, Matanuska, September 15, 1945, J. C. Chamberlin (USNM); ♀, Skagway, July 1, 1923, J. R. Kusche (Calif.). YUKON: ♀, Carcross, August 10, 1948, W. R. M. Mason (CNC). B.C.: ♀, Mt. Cheam [near Agassiz], August 17, 1922, R. Glendenning (CNC). WASH.: ♂, Big Four [Snohomish Co.], July 4, 1924, A. L. Melander (MCZ).

This subspecies occurs in the Hudsonian and Canadian Zones of Alaska and probably along the coast mountains of British Columbia and into Washington. The behavior of the species in Yukon and northern British Columbia is unknown.

Eudiaborus similis nebraskensis (*Davis*)

Diaborus nebraskensis Davis, 1897, Trans. Am. Entomol. Soc. 24 : 232 (o.d., ♂, Neb., key; type in ANSP).

The holotype remains after more than 50 years the only known specimen of its kind and the only specimen ever taken on the Great Plains south of Canada, yet is so remarkably different in coloration that it is here preserved as a distinct subspecies.

The much greater extent of yellow, covering more than half the body, is the distinguishing feature of this race.

Holotype

Male; morphology identical to that of *E. s. similis* (Davis) in all but minor details.

Color of head and thorax black, the following areas yellow: mouth parts, clypeus, face, inner orbit broadly to ocellus, cheek and temple to top of eye but not quite meeting inner orbit, postocciput below foramen magnum, scape below, all pronotum except a black mark in scrobe between opomiae, sides of mesonotum connecting with lines along notaulices which meet in a pair of discal spots, tegula, anterior third and lower third of mesopleuron, sternaulix, prepectus, scutellum, postscutellum, metapleuron, propodeum except areola and apex of petiolarea, all coxae and trochanters, fore and middle femora anteriorly. Remainder of all legs red except hind tarsus and apex of hind tibia, which are dusky. Abdomen black with the following yellow markings: apical third of petiole; lateral margins, and a pair of narrowing vittae along dorsal carinae of petiole; lateral margins, apical half, and a discal emargination of remaining tergites; these emarginations on tergites three and four red. Venter and genitalia yellow.

A female from Tower City, N.D., discussed under *E. s. hilaretinctus*, shows many markings suggestive of *nebraskensis*, and may be considered transitional.

Specimens Seen (*1* ♂)

Holotype.—Male; NEB [raska], no further data (ANSP).

The range of this race will probably be found to be the Upper Sonoran or Transition Zone of the Great Plains, and specimens could probably be collected on willows along water courses in early summer.

Eudiaborus pulchellus n. sp.

The female of this species may be recognized by the notched apical margin of the subgenital plate, the small sharply deflexed mucro (Fig. 52), and the geniculate, black-tipped third valvulae. The male may be distinguished by the parallel inner margins of the eyes and the peculiar coloration. It has two pale horizontal stripes on the lower part of the mesopleuron, and the hind legs have yellow coxae, red femora, and black tibiae and tarsi.

This species belongs in the *scalaris* group and is moderately primitive and isolated in its affinities.

Holotype

Female; length 6.5 mm.; temple 1.3 times as wide as eye; cheek, temple, and vertex moderately punctate; temple slightly flattened, receding below.

Mesopleuron densely and moderately coarsely punctate, with a small central glabrous area; mesonotal flange and axillary tongue well-developed; propodeum shining, weakly rugose, nearly completely carinate; basal carina

of the areola absent; costulae absent, but the first lateral areas at a higher level where they meet the second lateral areas; discoidella strongly pigmented; lower abscissa of nervellus 0.35 times total length.

Petiole, tergite two, and base of tergite three rugulose; remaining tergites finely punctate; subgenital plate boat-shaped, the apical margin sharp and centrally notched, upper and lower margins subparallel; mucro small and narrow but strongly deflexed; third valvulae geniculate; ovipositor straight, of the *scalaris* type (Figs. 52, 53).

Color black, the following parts yellow: mouth parts, clypeus, face, inner orbit to slightly above antenna, cheek and temple to one-quarter eye-height, scape below, propleuron, upper and lower margins of pronotum laterally, tegula, prepectus and mesosternum, tip of scutellum, postscutellum, apical medium triangular spot on each tergite, lateral margins of apical tergites, sternites and genitalia, but apex of third valvula black. Antenna brown below and apically. A reddish spot in front of middle coxa; lower half of metapleuron red. All legs red except black hind tarsus and tibia and the following yellow areas: fore and middle coxae and trochanters, hind coxa and trochanter below.

Allotype

Male; resembling the holotype except in the following characters: inner margins of eyes parallel, temple 0.8 times as wide as eyes in lateral view, mesonotal flange and axillary tongue not well developed, propodeum strongly and fully carinate but basal carina missing and apical carinae very strong, abdominal tergites beyond base of second smooth and finely punctate.

Color resembling that of the holotype except for the following differences: yellow of temples extending to one-third eye-height, yellow margins of pronotum much broader, subtegular ridge yellow, broad horizontal band at lower edge of mesopleuron yellow, horizontal band below sternaulix yellow, broad median area on mesosternum yellow, hind coxa entirely yellow except dark brown lateral areas, hind trochanters entirely yellow except upper part of basal trochanter which is dark brown, hind femur red, hind tarsus and tibia black, antenna black basally and dark brown apically, genitalia dark brown.

Egg

Ovate-reniform; stalk apicoventral, about as long as width of egg; anchor large; sagittal ridge short and papilliform (Fig. 51).

Variation

Female paratype.—Differing from the holotype as follows: lower third of mesopleuron yellow, sternaulix dark brown, no red in front of middle coxa, scutellum entirely yellow, hind coxa entirely yellow except lateral red patch.

Male paratype.—Resembling the allotype except as follows: temple as wide as eye, no median yellow stripe on mesosternum, antennal flagellum entirely black.

Specimens Seen (2 ♂♂, 2 ♀♀)

Holotype.—Female, Macdiarmid, Lake Nipigon, Ontario, July 11, 1923, N. K. Bigelow (CNC No. 6196).

Allotype.—Male, Queen's Park, Aylmer, Quebec, August 18, 1924, A. E. Graham (CNC).

Paratypes.—OREG.: ♂, Meacham, August 20, 1940, H. & M. Townes (Townes); ♀, Corvallis, July 1, 1919, other data illegible (Oreg.).

All specimens known were taken in the Transitional Zone. The species is active in midsummer.

Eudiaborus maculiventris (*Ashmead*)

This species is polytypic and circumpolar. Three subspecies are recognized, one in Europe, one in Alaska, and one in other sub-Arctic parts of North America.

Both sexes are easily distinguished by the exceptionally broad, flat temples and unusually coarse, close puncturation of the head and body, especially the completely punctate mesopleuron and coarsely punctate abdomen. In addition, the body is unusually hairy for the genus. The closest relatives are *E. promediatus* n. sp. and *E. dorsalis* (Cress.)

Eudiaborus maculiventris maculiventris (*Ashmead*)

Diaborus maculiventris Ashmead, 1896, Trans. Am. Entomol. Soc. 23 : 197 (o.d., ♂, Mt. Washington, N.H., at 5500–6000 ft., July 26, 1891, Albert Morse; type in USNM); Slosson, 1896, Entomol. News, 7 : 264 (N.H.); Davis, 1897, Trans. Am. Entomol. Soc. 24 : 230 (key, des., ♂, N.H.).

Diaborus ignipes Davis, 1897, Trans. Am. Entomol. Soc. 24 : 231 (o.d., ♀, N.H., key, des., ♀, N.H., Can.; type in ANSP).

The types of *E. maculiventris* (Ashm.) and *E. ignipes* (Davis) are male and female respectively of the same species as the long series from New England mountain tops demonstrates.

Females of this subspecies may be distinguished by the yellow inner orbits extending far above the antennal sockets. In addition, the prepectus is always yellow-marked laterally and the petiole distinctly basally auriculate. Males may be distinguished by the broadness of the facial black band, which is usually as wide as the clypeus, and by the broadly yellow lower margin of the pronotum.

This subspecies may have had a continuous transcontinental Nearctic refugium south of the ice during glaciation, whereas the other subspecies probably had a Palaearctic-Beringian refugium.

Plesiotype

Female; length 8 mm.; temple 1.5 times as wide as eye, unusually broad and flat; temples in dorsal view converging behind eyes at about 10°. Following areas closely and coarsely punctate: vertex, temple, face, all pleura, mesonotum, hind coxa, and tergites two and three.

Mesonotal flange and axillary tongue poorly developed; propodeal carinae low; areola with a transverse carinule; lower abscissa of nervellus 0.3 times total length; discoidella very weakly pigmented.

Petiole evenly rounded above, rugulose, dorsal carinae weak; and less than half length of petiole; subgenital plate boat-shaped, its upper and lower margins straight, converging at about 30°; apical margin at 80° to upper and slightly convex (Fig. 55); mucro sharp and decurved; ovipositor of *scalaris* type.

Color black, the following parts yellow: mouth parts, clypeus, face, inner orbit to top of eye, cheek and temple to one-third eye-height, upper and lower margins of pronotum laterally, propleuron, small median and lateral spots on prepectus, tegula, subtegular ridge, tip of scutellum, postscutellum, subtriangular spot at median apex of each abdominal tergite, apical tergites laterally, venter, genitalia. All legs red except dusky hind tarsus and the following yellow areas: fore coxa and trochanter, middle coxa and trochanter below. Antenna dusky basally but reddish apically.

Alloplesiotype

Male; like the plesiotype except as follows: temple narrower and less flat; areola with several transverse carinae and a median longitudinal one, giving a windowpane effect; petiole irregular and strongly rugulose; dorsal carinae strong and 0.7 times as long as petiole.

Color black, the following parts yellow: mouth parts, clypeus except basally, sides of face narrowly, small ventral spot on scape, malar space, upper and lower margins of pronotum laterally, tegula, tip of scutellum, apical 0.6 of fore coxa and apical 0.3 of middle coxa and their trochanters. All femora and tibiae red; hind coxa black; hind tarsus, antenna, and genitalia dusky.

Egg

Ovate-reniform; stalk very short, subapical, ventral; a very low sagittal ridge anterodorsally.

Variation

Females.—Length 7–8 mm.; temple 1.5–2.0 times as wide as eye. Yellow of inner orbit may extend only slightly above eye.

Males.—Length 6–8 mm.; temple 1.5–1.7 times as wide as eye; carinules of areola varying; lower abscissa of nervellus 0.25–0.35 times total length. Scutellum sometimes black; hind trochanter usually black; hind tibia sometimes dark apically; central black mark on face occasionally narrow or tapered toward clypeus.

Specimens Seen (*16* ♂♂, *13* ♀♀)

Plesiotype.—Female, Mt. Washington, New Hampshire, A. T. Slosson (AMNH).

Alloplesiotype.—Male, same data as plesiotype (AMNH).

Other specimens.—B.C.: ♂, Mt. McLean [near Lillooet], August 20, 1920 (CNC); ♀, Jesmond, 5500 to 7000 ft., July 23, 1938, J. K. Jacob (CNC) COLO.: ♀, Trail Ridge, Rocky Mountain National Park, 11,000 ft., August 25, 1933, M. & H. James (Townes). ALTA.: ♀, Cascade Mt., Banff, 7000 to 8000 ft., August 10, 1925, O. Bryant (USNM). SASK.: ♀, Prince Albert National Park, August 15, 1940, J. G. Rempel (Townes). QUE.: 2 ♂♂, Mt. Albert, Gaspé Pen., 3450 ft., July 18, 1940, A. E. Brower (Townes). NFLD.: ♀, Hopedale, Labrador, August 19, 1935, W. W. Perrett (British Museum). CANADA: ♀, no further data (ANSP). ME.: 2 ♀♀, Mt. Katahdin, 4800 and 5100 ft., August 1913, C.P.A. (USNM and Cornell). N.H.: ♂, Mt. Washington, Alpine Garden, July 11, 1931, A. L. Melander (MCZ); ♂, Mt. Washington, 5500 to 6000 ft., July 26–28, 1891, Albert Morse (holotype) (USNM); 2 ♂♂, ♀, Mt. Washington, A. T. Slosson (USNM and ANSP); ♂, White Mts., 1902 (MCZ); ♀, no other data (Type of *D. ignipes* Davis) (ANSP); 6 ♂♂, 2 ♀♀, no other data (ANSP). MASS.: ♂, Truro, September 4, A. P. Morse [mislabelled ?] (MCZ).

This subspecies is apparently common near the timberline in eastern Canada, New England, and the Rocky Mountains. It is also rarely taken well within the Canadian Zone. It is abundant in early August, very late for this genus.

Eudiaborus maculiventris sexmaculatus (*Ashmead*)

Diaborus sexmaculatus Ashmead, 1902, Proc. Wash. Acad. Sci. 4 : 221 (o.d., ♂, Popoff I., Alaska, July 9, 1899, Harriman Exped.; type in USNM).

This subspecies is distinguished from the typical one in the female sex by the yellow inner orbits, which do not extend above the antennal sockets. The males are distinguished from the typical subspecies by the narrow black band on the face and the black lower margin of the pronotum. The subspecies may be distinguished from *E. maculiventris boreoalpinus* Kerr. by the characters discussed thereunder.

Plesiotype

Female; resembling the plesiotype of the typical subspecies except that the tergites are less coarsely punctate.

Color resembling that of the typical plesiotype except in the following details: inner orbit yellow to antennal socket only, small basal black streak on clypeus, prepectus entirely black, apex of hind tibia darkened.

Alloplesiotype

Male; resembling the alloplesiotype of the typical subspecies except in the following details: length 7 mm., temple 1.6 times as wide as eye, areola with several transverse carinules.

Color resembling that of the typical alloplesiotype except as follows: central black stripe on face only as wide as interantennal distance, lower margin of pronotum black, apex of hind femur and middle tarsus dusky, hind tarsus black.

Variation

Females.—Length 5–9 mm.; temple 1.5–2.0 times as wide as eye; carinules of areola often absent; basal auriculae of petiole often scarcely evident, the petiole tapering evenly to the base. Prepectus in two-thirds of specimens bearing lateral yellow spots; apex of hind tibia often not darkened.

Males.—Length 5–7 mm.; temple 1.3–1.6 times as wide as eye; areolar carinules varying. Scape usually entirely black; legs varying from paler than those of alloplesiotype to almost entirely black except fore coxa.

Specimens Seen (*9* ♂♂, *32* ♀♀)

Plesiotype.—Female, King Salmon, Naknek River, Alaska, July 31, 1952, W. R. M. Mason (CNC).

Alloplesiotype.—Male, same data as plesiotype but J. B. Hartley (CNC).

Other specimens.—ALASKA: ♂, Popoff Island, July 9, 1899, Harriman Exped. (type) (USNM); 3 ♂♂, 28 ♀♀, King Salmon, Naknek River, July 31 to August 23, 1952, W. R. M. Mason and J. B. Hartley (CNC); 3 ♂♂, Mount McKinley Natl. Park, 1932, F. W. Morand (USNM); ♂, Summit Lake, Isabella Pass, July 9, 1952, W. R. M. Mason (CNC); ♀, Paxson Lodge, Gulkana, 4000 ft., August 4, 1952, W. R. M. Mason (CNC). N.W.T.: ♀, Reindeer Depot, MacKenzie Delta, August 3, 1948, J. R. Vockeroth (CNC); ♀, Cameron Bay, Great Bear Lake, August 4, 1937, T. N. Freeman (CNC). MAN.: ♀, Churchill, August 7, 1937, W. J. Brown (CNC).

This subspecies occurs near the timberline in Alaska and across the Arctic timberline in Western Canada as far east as Hudson Bay.

Eudiaborus maculiventris boreoalpinus Kerrich

This subspecies is extremely close to *sexmaculatus* (Ashm.), and single individuals of either sex often cannot be distinguished. The petiole of this subspecies is usually more evenly tapered toward the base with the basal auriculae less evident. The females of the Old World subspecies have entirely black prepectus while Alaskan specimens often have yellow lateral marks. Males from the Old World have the scutellum usually entirely black and antennal scape yellow below, while Alaskan specimens have a yellow-tipped scutellum and scapes usually entirely black.

Specimens Seen (*2* ♂♂, *2* ♀♀)

Paratypes.—GERMANY: ♂, ♀, Bavaria, Allgau, Osterach-Tal at 1600 meters, August 8, 1949, G. Heinrich; ♂, ♀, Silesia, Glatzer Schneeberg, August 2 and 11, 1921, K. Hedwig.

Kerrich (1) records this subspecies from the Alps, Scandinavia, and Scotland.

Thanks are due Mr. Kerrich for making possible the loan of this Palaearctic material.

Eudiaborus promediatus n. sp.

This is one of the most difficult species of the genus to recognize. The name *D. mediatus* (Cresson) has been associated with it by Davis and all subsequent

authors in error. Cresson himself apparently determined it as *Cteniscus sexlituratus* (Gravenhorst).

Three subspecies are recognized: the typical one with a transcontinental distribution from the Hudsonian to the Transitional Zones; another in the Carolinian Zone; and a third in the mountains of Arizona and New Mexico.

The female subgenital plate (Fig. 57), genitalia, and the poorly developed mesonotal flange (Fig. 12) are sufficient to distinguish that sex. The male is determined mainly by negative characters, but the following positive ones should help: temple 1.0–1.4 times as wide as eye, usually wide, gibbous below, and finely punctate; propodeal carinae usually strong, lateral angles of the apical carina strongly raised and subtending longitudinally rugose areas; face always yellow.

The closest relatives are *E. maculiventris* (Ashmead), and *E. dorsalis* (Cresson).

Eudiaborus promediatus promediatus *n. subsp.*

Cteniscus mediatus Cresson, Provancher, 1879, Nat. Can. 11 : 263.—Provancher, 1883, Faune Entomol. Can. Hymen., p. 421.

Diaborus mediatus (Cresson) Hopping, 1937, Can. Entomologist, 69 : 248 (host, B.C.).

This subspecies may be distinguished from *cressoni* as follows: female with entirely black mesopleuron and scarcely even a trace of anterior flange on the egg; the male with entirely black propleuron, mesosternum, and prepectus. The female may be distinguished by the same characters from *arizonicus*.

Transitional forms between this subspecies and *cressoni* have been taken in Ontario and New York and may be expected to occur in other Transitional Zone localities.

Holotype

Female; length 7 mm.; temple 1.5 times as wide as eye, gibbous below; cheek, temple, and vertex densely, but not coarsely, punctate.

Mesonotal flange and axillary tongue poorly developed; mesopleuron densely and coarsely punctate except a small area about mesopleural pit; metapleuron with a curved horizontal carina; propodeum completely carinate, dorsolateral angles of apical carina strong; surface of propodeum rugulose; discoidella pigmented; lower abscissa of the nervellus 0.25 times total length.

Petiole 1.3 times as long as wide at apex; first three tergites rugulose, remainder smooth; subgenital plate boat-shaped, upper and lower margins subparallel in lateral view and both at right angles to concave apical margin; apical third of upper margin convex (Fig. 57); mucro terete, decurved at 45°; third valvulae geniculate; ovipositor curved upwardly, second valvulae strongly tapered at 0.6 distance to apex.

Color is black with the following parts yellow: mouth parts, clypeus, face, inner orbit narrowly to top of eye, scape below, lower parts of cheek and postgena to 0.4 eye-height, propleuron, upper and lower margins of pronotum

laterally, tegula, subtegular ridge, apex of scutellum, postscutellum, mesosternum and prepectus excepting dark areas behind fore coxa, a subtriangular spot with base on median apex of each abdominal tergite, third and following tergites laterally, venter except a pair of dark marks on sternite two, genitalia. Antenna red except dorsobasal dark area. All legs red except for dusky hind tarsus and the following yellow areas: fore and middle coxae and trochanters, ventral parts of hind coxa and trochanter.

Allotype

Male; resembling the female except in the following details: length 6.5 mm.; temple 1.4 times as wide as eye; cheek thickly and coarsely punctate; propodeal carinae all strong, median longitudinal basally, and apical laterally, especially so; petiole 1.1 times as long as wide at apex; tergites three to six rugulose basally.

Color like that of the female with the following exceptions: only anterior half of cheek yellow to 0.3 eye-height; entire thorax black except tegula, and upper and lower margins of pronotum laterally; hind coxa and trochanter red, paler below and dusky basally; tergite five not yellow laterally; antenna dark above, brown below; middle coxa reddish basally; hind tibia with a subbasal dark annulus and apical 0.4 dark; tergites two and three, dark bordered.

Egg

Ovate-reniform; stalk posteroventral, short and thick; anterodorsal sagittal ridge scarcely visible.

Variation

Female paratypes.—Length 5.5–8 mm.; temple 1.3–1.8 times eye width; carinae of propodeum varying from strong to weak in central area; lower abscissa of nervellus 0.2–0.35 times total length. Hind tibia usually darkened apically and sometimes also with a subbasal dusky annulus; in extreme cases hind tibia and tarsus almost entirely black. The Vancouver specimens have a narrow replacement of black by red in the thoracic areas where yellow and black meet.

Male paratypes.—Length 5–7.5 mm.; temple 1.2–1.5 times eye width; mesopleuron usually more coarsely punctate than that of female; petiole 1.1–1.4 times as long as apical width; lower abscissa of nervellus 0.2–0.3 times total length. Apex of scutellum, and postscutellum, often yellow in more southerly specimens; hind coxa varying from red to black, with lower part usually yellow; hind tibia and tarsus sometimes black; antennal flagellum sometimes entirely black.

Specimens Seen (24 ♂♂, 60 ♀♀)

Holotype.—Norman Wells, Northwest Territories, July 6, 1949, W. R. M. Mason, swept from *Salix* (CNC No. 6197).

Allotype.—Male, same data as holotype but July 9 (CNC).

Paratypes.—ALASKA: 8 ♀♀, Summit L., Isabella Pass, July 9, 1951, W. R. M. Mason (CNC); ♂, Paxson Lodge, Gulkana, July 31, 1951, W. R. M.

Mason (CNC); ♀, Mile 103, Steese Highway, June 22, 1951, W. R. M. Mason & J. R. McGillis (CNC); ♀, Mile 213, Richardson Highway, July 8, 1951, W. R. M. Mason (CNC); 3 ♂♂, 3 ♀♀, Nome, July 15 to 23, 1951, D. P. Whillans (CNC); 2 ♂♂, 2 ♀, King Salmon, Naknek R., July 11 to August 11, 1952, W. R. M. Mason & J. B. Hartley (CNC); 5 ♀♀, Naknek, July 3 to August 8, 1952, W. R. M. Mason (CNC), ♂, Savonoski, Naknek Lake, July 27, 1919, J. S. Hine (Townes). YUKON: 2 ♀♀, ♂, Mile 94, Haines Cut-Off Road, Chilkat Pass, 3200 ft., July 17, 1948, Mason & Hughes (CNC). N.W.T.: ♂, 14 ♀♀, same data as holotype but ♀♀, June 27 to July 23, ♂, June 17 (CNC). B.C.: ♂, Mile 75, Haines Cut-Off Road, Chilkat Pass, 3500 ft., July 16, 1948, Mason & Hughes (CNC); ♀, Agassiz, April 30, 1927, H. H. Ross (CNC); 3 ♀♀, Shuswap Falls, May 21, 1947, ovipositing on larvae of *Nematus nigriventris*, B. A. Sugden (CNC); 5 ♂♂, 2 ♀♀, Taft, May 15, 1944, ex *Nematus nigriventris*, Hopping & Morgan (CNC); 3 ♂♂, 7 ♀♀, Vancouver, August 24 to September 3, 1931, ex *Hemichroa crocea*, H. B. Leech (CNC); 2 ♂♂, Vancouver, June 9, 1932, G. R. Hopping (CNC & Townes); ♂, ♀, Vancouver, August 15, 1932, ex *Hemichroa crocea*, Hopping & Leech (CNC). ALTA.: ♀, Edmonton, June 16, 1937, F. O. Morrison (Townes). SASK.: ♀, Saskatoon, November, 1929, E. McMillan (CNC). COLO.: ♀, Lyons, June 14, 1948, Townes family (Townes). MINN.: ♀, Hennepin Co. (Minn.). MICH.: ♀, Manistee Co., July 26, 1940, R. R. Dreisbach (Townes). ONT.: ♀, Trenton, July 16, 1901, Evans (CNC). QUE.: ♂, ♀, Fort Chimo, June 26 to 29, 1948, H. H. MacLeod (CNC); ♂, Harrington Harbor, July 3, 1929, W. J. Brown (CNC). NFLD.: ♂, St. John's, Forest Insect Survey winter emergent, ex ? *Croesus latitarsus* (CNC). N.S.: ♀, Baddeck, July 21, 1938, J. McDunnough (CNC).

The following specimens are not included in the type series because they show characters intergrading with subspecies *cressoni*: (The first two records have probably been influenced by artificial conditions, especially incubation.) ♂, Dryden, Ont., Forest Insect Survey winter emergent ex *Arge virescens* (CNC); 3 ♂♂, Timmins, Ont., July 26, 1940, Forest Insect Survey, associated with *Trichiocampus viminalis* (CNC); 3 ♂♂, 5 ♀♀, Cornell Lot No. 248 but no locality data [probably from Ithaca, N.Y.], August 18 to 21, 1889 (CU).

This subspecies has a transcontinental range in the Hudsonian, Canadian, and Transitional Zones.

Records of captures indicate a single generation flying in late June and July in the Hudsonian and Canadian Zones. In the Transition Zone of southern British Columbia there may be a double annual generation, males having been taken in mid-June and again in late August and September. There is no indication that a double generation occurs in this subspecies in the East.

The most reliable host records are in the Nematinae (Tenthredinidae); *Nematus currani* Ross and *Hemichroa crocea* (Fourcroy). More doubtful are the queried records of *Trichiocampus viminalis* (Fall) and *Croesus latitarsus* Norton. One record from an Argid, *Arge virescens* Klug, may be accepted with caution until verified.

Eudiaborus promediatus cressoni *n. subsp.*

Cteniscus sexlituratus (Gravenhorst) Cresson, 1868, Trans. Am. Entomol. Soc. 2 : 91 (misdet.).

Diaborus mediatus (Cresson) Davis, 1897, Trans. Am. Entomol. Soc. 24 : 232 (in part, misdet.).

This subspecies is readily distinguished from the typical one by the strongly carinate egg and by the extent of yellow on the mesopleuron, which in the female bears a horizontal stripe to the level of, or above, the sternaulix. The male may be distinguished from the typical subspecies by the completely yellow propleuron and median yellow area on the prepectus and adjacent part of the mesosternum.

The female may be distinguished from *arizonicus* by the scutellum being yellow apically only, and the inner orbit extending only slightly above the antennal socket.

Holotype

Female; resembling the holotype of the typical subspecies except in the following details: length 6 mm., temple only 1.15 times as wide as eye, petiole only 1.1 times as long as wide apically, petiole and tergites much less coarsely rugulose, upper margin of subgenital plate convex for most of its length.

Color like that of *promediatus* except the following parts yellow: entire prepectus, lower third of mesopleuron, lower part of metapleuron, and all but dorsal surfaces of the hind trochanter and coxa. Sternaulix dark; apical 0.4 and a subbasal annulus on hind tibia dark.

Allotype

Male; similar to the holotype of *cressoni* except in the following details: length 5.5 mm.; temple as wide as eye, dorsolateral angles of the apical carina of propodeum subtending longitudinal rugosities, petiole 1.3 times as long as its apical width.

Color resembling that of the holotype of *cressoni* except in the following ways: anterior 0.6 of cheeks to one-third eye-height yellow, only small median spots on mesosternum and prepectus yellow.

Egg

Resembles that of the typical subspecies, but has an anterodorsal sagittal carina.

Variation

Female paratypes.—Length 3.5–7 mm. (smaller specimens apparently dwarfed by rearing conditions); temple 1.1–1.6 times as wide as eye; dorsolateral angles of apical carina usually subtending longitudinally rugose areas; petiole 1.0–1.3 times as long as apical width. Metapleuron often black or reddish; degree of darkening of hind leg variable; on basal areas of tergites one, two, and three, and parts of propodeum, black sometimes replaced by dark red.

Male paratypes.—Length 3.5–7 mm. (smallest specimens probably dwarfed by rearing); temple 1.0–1.4 times as wide as eye, moderately to finely punctate; propodeum, petiole, and tergites often rather smooth in small specimens, or very irregular and rugose in larger ones. Upper parts of propleuron sometimes black; antenna and hind tibia sometimes entirely reddish.

Specimens Seen (22 ♂♂, 16 ♀♀)

Holotype.—Female, Lacey, Virginia, September 12, 1912, ex *Pteronidea winnonae* (Rohwer) on Salix, Wm. Middleton (USNM No. 59401).

Allotype.—Male, same data as holotype but September 16 (USNM).

Paratypes.—VA.: ♂, 4 ♀♀, same data as holotype but September 12–21 (USNM); 2 ♂♂, Falls Church, September 12–16, 1912, ex *Pteronidea winnonae* (Rohwer) on Salix, Wm. Middleton (USNM); 4 ♂♂, ♀, Blacksburg, September 19, 1922, ex *Pteronidea mendicana* on Salix, Wm. Middleton (USNM). MD.: 6 ♂♂, ♀ Plummer's Island, October 14, 1909, A. K. Fisher (PRR). N.Y.: ♂, Westbury, September 11, 1916, ex *Pteronidea plesia* (Rohwer), Wm. Middleton (USNM). CONN.: 2 ♂♂, 2 ♀♀, East River, May 31, 1917, ex *Pteronidea quinque-odorata* (Dyar), C. R. Ely (USNM). R.I.: 2 ♂♂, 2 ♀♀, Westerly, August 5, 1922, Gypsy Moth Survey, ex *Tenthredinid* (USNM); ♂, Newport, Leidy (ANSP). MICH.: ♀, South Haven, June 1, 1891 (ANSP). PA.: ♀, Spring Brook, June 27, 1945, H. K. Townes (Townes). ONT.: ♀, Blackburn, June 18, 1941, G. S. Walley (CNC). NO DATA: 2 ♂♂, 2 ♀♀, ex *Nematus salicis-odoratus*, H. G. Dyar (USNM).

One female [Marlton, N. J., September 4, 1924, F. J. Cronin (USNM)] is excluded from the type series. The color pattern of this specimen is well within the range of that of the typical subspecies but the locality data, if correct, places it far out of natural range.

The subspecies occurs mainly in the Carolinian Zone but one or two specimens have been taken in the Transitional Zone. In this zone it intergrades with typical *promediatus*.

Because the most known specimens of the subspecies were reared it is hard to make conclusions about seasonal distribution. Specimens from the southern part of its range have all been taken very late in the year during September and October but in the northern part of the range evidence seems to indicate early- and mid-summer activity.

The recorded hosts are all, perhaps, one species of Nematinae (Tenthredinidae): *Nematus odoratus* (Marlatt).

Eudiaborus promediatus arizonicus *n. subsp.*

This subspecies is distinct from the others in the greater extension of yellow markings, especially those of the inner orbits, mesonotum, scutellum, and abdomen.

Holotype

Female; resembling holotype of typical subspecies except in the following details: cheek and temple not densely punctate, cheek more strongly gibbous below.

Color differing from that of the holotype of typical subspecies as follows: yellow of inner orbit extending almost to lateral ocellus; temple and post gena yellow to half eye-height and to foramen magnum; lower margin of pronotum, and scutellum, entirely yellow; lower third of mesopleuron yellow, leaving sternaulix black; yellow spots about the anterior end of notaulix; yellow triangles of tergites with ill-defined anterior extension.

Male. Unknown.

Egg

Differing from that of the typical holotype in having a prominent anterior flange only about twice as long as tall.

Variation

Female paratypes.—Length 5–7 mm.; temple 1.2–1.5 times eye-width; costula sometimes weak. Upper part of inner orbit sometimes detached; metapleuron sometimes yellow; anterior extensions of abdominal triangles sometimes absent.

Specimens Seen (7 ♀ ♀)

Holotype.—Female, Oak Creek Canyon, Arizona, May 18, 1947, H. & M. Townes (Townes).

Paratypes.—ARIZ.: 4 ♀ ♀, same data as holotype but May 18–21 (Townes); ♀, Mt. Lemmon Lodge, Sta. Catalina Mts., June 13, 1947, A. T. McClary (Townes). N.M.: ♀ Pecos, June 23, C. D. Cockerell (ANSP).

This subspecies is known from only three localities in the Southwest. The northern limit is probably no further north than southern Colorado, but the southern or western limits are quite unknown.

Eudiaborus dorsalis (*Cresson*)

Cteniscus dorsalis Cresson, 1864, Proc. Entomol. Soc. Philad. 3 : 282 (o.d., Ill., "♂" is ♀, type in ANSP).

Cteniscus mediatus, Cresson, 1864, Proc. Entomol. Soc. Philad. 3 : 282 (o.d., Ill., ♂, type in ANSP).—Provancher, 1879, Natl. Can. 11 : 263 (key, des., ♀, Que.).

Diaborus mediatus (Cresson), Davis, 1897, Trans. Am. Entomol. Soc. 24 : 232 (in part, Ill.).

Diaborus dorsalis (Cresson), Davis, 1898, Trans. Am. Entomol. Soc. 24 : 232 (key, des., Ill.).

Diaborus ornatus (Walsh), Johnson, 1927, Biol. Survey Mt. Desert Region, 1 : 134 (misdet., Me.).

The ground color of the female ranges from black to red, while that of the male remains black. It is thus easily seen how Cresson, who mistook the sex of the female, could have believed himself to have two distinct species in the original type series. Unfortunately Cresson's type of *mediatus* (really the male of *dorsalis*) has been wrongly associated by Davis and subsequent authors with another species (*E. promediatus*) which is described as new herein.

Both sexes are most easily recognized by the combination of poorly developed mesonotal flange and the very broad yellow inner orbit extending to the top of the eye. The female is further distinguished by the long mucro and very short, basally truncate, third valvulae (Fig. 60).

This is one of the more specialized species of the *scalaris* group.

Plesiotype

Female; length 4 mm.; temple 1.2 times as wide as eye; temple, cheek, and vertex finely and sparsely punctate.

Mesopleuron coarsely and densely punctate with only a small speculum; mesonotal flange poorly developed; axillary tongue appressed, scarcely visible from above; propodeum smooth, rounded, slightly rugulose, all carinae well developed but costulae weak; median carina of petiolarea strong; discoidella not at all pigmented; lower abscissa of nervellus 0.2 times total length.

Petiole, and tergites two and three basally, weakly longitudinally rugulose, remainder polished and finely punctate; subgenital plate boat-shaped, upper and lower margins subparallel, apical margin perpendicular, inflexed in its upper 0.3; mucro straight, basally flattened, one-third as long as apical margin, deflexed at 25° (Fig. 63); third valvulae very abruptly geniculate, only as long as tall; second, valvifers almost perpendicularly truncate; ovipositor of *scalaris* type, but straight.

Color red, the following parts yellow: mouth parts, clypeus, scape and pedicel below, face, inner orbit broadly to top of eye, cheek and temple to 0.4 eye-height, lower 0.7 of propleuron, upper and lower margins of pronotum laterally, tegula, subtegular ridge, apex of scutellum, postscutellum, small midventral spot on mesosternum, fore and middle coxae and trochanters, hind trochanter ventrally, mid-apical triangular spot on each tergite, apical tergites laterally, venter and genitalia.

Alloplesiotype

Male; resembling the plesiotype except in the following details: mesopleuron moderately finely but densely punctate; propodeum rugulose.

Color black, the yellow marks as in the plesiotype with the following exceptions: mesosternum entirely black, hind coxa ventrally and apically yellow, hind tibia and hind tarsal joints dusky apically, posterior margin of tergite two red, antenna entirely brown.

Egg

Ovate; stalk short, posterior, and directed ventrally; no flange visible.

Variation

Females.—Length 4–6.5 mm., but the larger sizes scarce; temple 1.0–1.2 times as wide as eye; discoidella sometimes weakly pigmented; lower abscissa of nervellus 0.15–0.2 times total length; upper 0.2–0.4 of the apical margin of subgenital plate inflexed, mucro 0.3–0.5 times as long as apical margin; specimens from the prairie and great plains region tending to have mucro decurved to 45° and apical margin evenly rounded with crenulate teeth

(Fig. 60). Ground color red or black, or variegated with intermediate hues. In the transition from red to black, the black appears first as a darkening of the red hue on the head, then on the thorax and apex of the abdomen. Parts of the thorax, especially the notaulices, lateral margins of the mesonotum, sternum, and propodeum, resist this darkening. The last parts to become black are the three basal tergites of the abdomen. The extreme red is represented by specimens from Illinois, White Fox, Sask., and Camino, Calif., while the extreme black is known from Alaska, Truro, N.S., Estes Park, Colo., and Churchill, Man. The following parts are always reddish: antenna below and apically, hind coxa and all legs, apical margin of tergite two. Yellow markings vary from those of plesiotype only as follows: usually a lateral spot on prepectus, usually hind coxa ventrally.

Males.—Length 3.5–4.5 mm.; temple 1.0–1.2 times as wide as eye; costulae usually as strong as other carinae; lower abscissa of nervellus 0.18–0.35 times total length.

The ground color is black in all known specimens. The extent of yellow varying as follows: lower half of three-quarters of propleuron, usually a lateral spot on prepectus, hind coxa often entirely yellow or with small brown basal marks. In the most lightly colored specimens the notaulices may be outlined in yellow with mesonotum partly brown and second and third tergites brown. Proximal and distal margins of tergite three usually red.

Specimens Seen (19 ♂♂, 19 ♀♀)

Plesiotype.—Female, Camino, California, June 27, 1948, Townes family (Townes).

Alloplesiotype.—Male, Fish Camp, California, July 16, 1948, Townes family (Townes).

Other specimens.—ALASKA: Kodiak, Big Delta, Naknek, King Salmon, Naknek R. ALTA.: Beaverlodge, Edmonton. SASK.: White Fox. MAN.: Churchill. CALIF.: Fish Camp, San Diego Co. COLO.: near Estes Park. ONT.: Point Alexander. N.S.: Truro. ME.: Bar Harbor, Mt. Desert. N.H.: Randolph. N.Y.: ? Adirondak Mts., Lake Placid. MICH.: Midland Co. ILL.: (Types). (No further data.)

This species is very wide ranging and apparently has a transcontinental occurrence from the Hudsonian to the Upper Austral Zones.

In the Northeast adults are active from late June till August and perhaps some females live until autumn.

Orthomiscus new genus

Type of the genus: *Orthomiscus platyura* n. sp.

This genus is formed for two new Nearctic species which fall between *Cteniscus* Auct. and *Acrotomus* Holmgren. They differ from the latter genus in having the lower mandible tooth equal to or smaller than the upper. From *Cteniscus* they are easily distinguished by the single-stalked egg. They are further distinguished by the pinched female subgenital plate, unusually large head, and pair of divergent basal grooves on the second tergite.

The most closely related genus is *Acrotomus* Hlgr. There is considerable external resemblance to species of the *A. laetus* group, but this is probably largely the result of convergence in habitus. The eggs and mandibles differ widely. Probably both *Orthomiscus* and the *laetus* group evolved from a small, stocky, short-petioled ancestor.

Despite the superficial resemblance, this genus is not closely related to *Cteniscus*. Wide differences in the eggs, ovipositor, and subgenital plate preclude that possibility. The relationship to *Eudiaborus* Kerr. may be as close.

Description

Head subcuboid, in dorsal view much broader than thorax; temples not at all converging behind eyes, in lateral view much wider than eye; vertex in lateral view raised well above top of eye; cheek buccate; occipital and hypostomal carinae complete but not raised, meeting well above mandibular condyle; face strongly elevated centrally but depressed laterally; clypeus about 0.4 times as long as wide, apically subtruncate; lower mandible tooth equal to, or slightly smaller than, upper; antenna long and thin, middle joints over twice as long as wide; pedicel longer than wide; all cephalic puncturation fine.

Notaulix sharply defined basally but present as a shallow groove to behind middle of mesonotum; subtegular ridge simple; prepectus simple, its carina not strongly raised; mesonotal flange and axillary tongue poorly developed; propodeum smooth, evenly rounded, and fully areolated; areola much longer than wide and lacking a basal carina; all thoracic puncturation fine; legs long and slender; tarsal claws with three to six basal teeth.

Petiole slender, about twice as long as apical width, evenly broadening from a narrow base, not auriculate; dorsal surface of petiole smooth and highly polished with a pair of almost percurrent carinae, straight in lateral view; remaining tergites smooth, polished, and only very finely punctate; second tergite of female with a pair of divergent basal grooves as in *Diaborus*, but these grooves indistinct in male; female subgenital plate centrally folded and thin; ovipositor evenly decurved and not deep; first valvulae thin; third valvulae simple (Figs. 64, 67).

The egg is ovate-reniform, with a single short ventral or subapical stalk.

Distribution

The genus is only known from temperate eastern North America and California.

KEY TO SPECIES OF *Orthomiscus*

Abdomen black and yellow; scutellum black, or yellow only at the tip; yellow of cheeks usually extending to less than half the eye-height ..... *leptura* n. sp.

Abdomen beyond petiole reddish; scutellum mostly yellow; yellow of cheeks extending nearly to the top of the eyes ..... *platyura* n. sp.

Orthomiscus leptura n. sp.

This species may be distinguished from the other one in this genus by the key characters. In addition the anchor of the egg is small and simple (Fig. 72), and the ovipositor and third valvulae are much narrower (Fig. 65).

Holotype

Female; resembles the generic description except as follows: length 6 mm., subgenital plate sharply folded on midventral line and obtusely pointed but truncate at extreme apex, second valvulae about as wide and deep as flagellar segments and not tapered but abruptly rounded off apically, third valvulae as wide as deep and about twice as long as deep, parallel-sided but rounded apically (Fig. 64).

Color black, the following parts yellow: mouth parts, clypeus, face, inner orbit nearly to top of eye, cheek, temple, and postgena to slightly more than half eye-height, scape and pedicel below, propleuron, lower lateral half and posterior margin of pronotum, subtegular ridge, tegula, prepectus, mesosternum, lower half of mesopleuron, trace at tip of scutellum, apical margins of tergites two and three with median cephalad extensions, apical tergites laterally, venter, genitalia, and extreme apex of abdomen. Scape and pedicel above, and flagellum of antenna pale reddish, the basal segments dark with yellow apices. All legs pale reddish; fore and middle coxae and trochanters yellow; hind coxa yellow with brown areas basally above and laterally; hind femur reddish brown.

Allotype

Male; like the holotype except as follows: eye larger; propodeum smaller, its surface weakly rugose; grooves of second tergite shorter and shallower.

Color like that of the holotype with the following exceptions: yellow of inner orbit extending only to antenna; postgena black; cheek yellow only to one-third eye-height; yellow of prothorax confined to lower corner and stigmal lobe; prepectus, mesosternum, pleuron, and scutellum black; yellow of tergites more extensive, third tergite centrally brown; apical tergites, genitalia, and extreme abdominal apex reddish.

Egg

Short, ovate-reniform; stalk very short, posteroventral; foot small and oval.

Variation

Female paratypes.—Length 6–8 mm.; tip of scutellum black to yellow; brown of hind leg from pale to very dark; median yellow spots on abdomen from large triangles filling half tergites 2–4 to narrow apical margins.

Male paratypes.—Length 5–8 mm. Some specimens from Ontario and California with yellow markings in the region of the prepectus and sternaulices; brown of hind leg varying from pale to very dark; median yellow spots on abdomen varying from large triangles filling over half tergites two to four, to a narrow apical margin on tergite two and a poorly defined median area on tergite three.

Specimens Seen (*10* ♂♂, *9* ♀♀)

Holotype.—Female; Pinkham Notch, New Hampshire, June 25, 1938, H. & M. Townes (Townes).

Allotype.—Male; Mt. Madison, New Hampshire, June 24, 1938, H. & M. Townes (Townes).

Paratypes.—N.H.: 2 ♂♂, same data as allotype (Townes). VT.: ♂, L. Willoughby, 1400 ft., June 17, 1945, C. P. Alexander (Townes); ♀, L. Willoughby, 2500 ft., June 25, 1945, C. P. Alexander (Townes). QUE.: ♂, ♀, Stoneham, June 21, 1938, H. & M. Townes (Townes); ♀, Gatineau Park, June 8, 1954, W. R. M. Mason (CNC). ONT.: ♂, Dow's Swamp, Ottawa, June 12, 1946, G. S. Walley (CNC); ♂, Dow's Swamp, Ottawa, August 9, 1947, W. R. M. Mason (CNC). CALIF.: ♀, Coffee Creek, Trinity Co., June 19, 1934, G. E. Bohart (Townes); ♂, Siskiyou Co., May 29, 1911, F. W. Nunenmacher (USNM); ♀, Humboldt Co., May 14, 1911, F. W. Nunenmacher (USNM); 2 ♀♀, Camino, June 27 & 30, 1948, H. M. G. & D. Townes (Townes); ♂, Yosemite, June 14, 1935, A. L. Melander (MCZ); ♂, Mill Valley, Marin Co., March 12, 1926, M. C. Van Duzee (Calif.); ♀, Redwood Coralitos, St. Cruz Mts., May 13, 1907, J. C. Bradley (CU).

No subspecific differentiation between the Californian and Eastern populations is evident in the small samples studied.

This species occurs in the Transition and perhaps Canadian Zones of the New England – St. Lawrence area in the East. It reappears in the Transition Zone of Northern California. There is insufficient evidence to indicate whether the range is continuous.

Adults appear in early summer throughout most of the range.

Orthomiscus platyura n. sp.

This species may be distinguished from *O. leptura* by the key characters, and by the egg, which has a four-lobed anchor as large as itself (Fig. 70), and by the much broader ovipositor and third valvulae (Fig. 68).

Holotype

Female; resembling the generic description except as follows: length 6.5 mm.; subgenital plate only weakly folded and apically obtuse; ovipositor stout, broader than deep except apically, and over twice as wide as flagellar segments; third valvulae as deep as long and tapered strongly to a rounded apex (Fig. 67).

Color of head and thorax black with the following parts yellow: mouth parts, clypeus, face, inner orbit to top of eye, postgena, cheek and temple to 0.75 eye-height, prothorax except dusky saddle, tegula, subtegular ridge, scutellum and postscutellum, lower half mesopleuron, mesosternum. Fore and middle coxae and trochanters yellow; hind coxa and remainder of all legs pale reddish. Antenna red, basal flagellar segments dusky with yellow apices. Petiole and second tergite black with lunate median apical yellowish marks; remainder of abdomen reddish brown.

Egg

Short, ovate. The lower side flat and bearing on nearly half its length a very short but exceedingly wide stalk, to which is attached a large anchor enclosing most of the egg. This anchor bearing two long posterior and two long anterolateral arms extending toward the dorsal surface of the egg (Fig. 71).

Allotype

Male; resembling the holotype except that the length is 6 mm.

Color like that of the holotype with the following exceptions: temple yellow to only slightly over half eye-height, prothorax entirely yellow, lower 0.6 of mesopleuron yellow, all coxae and trochanters yellow, hind legs pale brown, basal and lateral third of second tergite black with remainder red-brown, remaining tergites red-brown with dark laterobasal areas.

Variation

Female paratypes.—Length 5–8 mm.; prothorax varying from entirely yellow to entirely black except lower margin and upper corner; yellow of mesopleuron sometimes extending up to both wing bases leaving two black spots, or reduced to a broad line adjacent to the sternum which, in such cases, is mostly black. Metapleuron may be yellow below; hind coxa from entirely yellow to brown-sided; the palest abdomens entirely pale red with base of tergite two brown; darkest abdomens a little darker than that of the type.

Male paratypes.—Length 5–6 mm.; temple 0.5–0.7 eye-height; prothorax sometimes with dusky saddle; base of scutellum sometimes black.

Specimens Seen (*5* ♂♂, *20* ♀♀).

Holotype.—Female, Westerly, Rhode Island, June 9, 1936, M. Chapman (Townes).

Allotype.—Male, same data as holotype but June 11 (Townes).

Paratypes.—ME.: ♀, Stratton, Franklin Co., August 19, 1945, J. C. Bradley (CU). VT.: ♀, Mt. Equinox, near Manchester, June 3, 1910 (MCZ); ♀, Laurel Lake, Jacksonville, July 15, 1939, H. D. Pratt (Minn.). N.H.: ♀, Bretton Woods, June 27, 1913 (MCZ). MASS.: ♀, Great Barrington, June 15, 1915, C. W. Johnson (MCZ). CONN.: ♀, Redding, June 1929, A. L. Melander (MCZ); ♀, Ledyard, August 4, 1946, M. Townes (Townes). N.Y.: ♀, Ithaca, June 1905, MacGillivray (CU); ♀, MacLean Bogs, Tompkins Co., June 30, 1939, J. G. Franclemont (Townes); ♀, Millwood, June 21, 1936, H. K. Townes (Townes). QUE.: ♀, Hull, June 16, 1934, W. J. Brown (CNC); ♀, Nominingue, June 5, 1941, O. Peck (CNC). MICH.: ♀, Roscommon Co., July 14, 1945, R. R. Dreisbach (Dreisbach); ♀, Midland Co., June 10, 1939, R. R. Dreisbach (Dreisbach); ♀ Mecosta Co., July 4, 1940, R. R. Dreisbach (Dreisbach). PA.: ♀, Moosic, Lackawanna Co., August 18, 1945, H. H. Swift (Swift); ♀, Trout Run, May 29, 1938, H. K. Townes (Townes); ♀, Spring Brook, Lackawanna Co., June 27, 1945, H. K. Townes (Townes). N.J.: ♂, Tabernacle, June 11, 1939, H. & M. Townes (Townes). M.D.: ♀, Glen Echo, 1916, R. M. Foster (USNM). ALA.: 2 ♂♂, Pyziton, Clay Co. (USNM). NO DATA: ♂ [probably Ottawa] (CNC).

This species occurs in the Alleghenian and Carolinian Zones, extending a little into the Canadian Zone.

Adults appear in early summer.

Acknowledgments

I wish to express thanks to Dr. J. C. Bradley, Cornell University, Dr. V. S. L. Pate, Philadelphia Academy of Sciences, Dr. H. K. Townes, Raleigh, N.C., and Mr. G. S. Walley, Systematic Entomology Unit, Ottawa, for advice and suggestions during the study. Mr. G. J. Kerrich, British Museum (Natural History), while studying the Old World Cteniscini, gave invaluable assistance by lending manuscripts and making available loans of vital Palaearctic species. Lastly, I wish to thank the many curators and owners of collections who lent material.

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(Figs. 1-73 and their captions on pages 69-73.)

FIGS. 1-12

FIG. 1. *Eudiaborus promediatus* n. sp., subtegular ridge. FIG. 2. *Smicroplectrus jucundus* (Hlgr.) subtegular ridge. FIG. 3. *S. robustus* Walley, subtegular ridge. FIG. 4. *S. annulipes* (Cress.) subtegular ridge. FIG. 5. *Eudiaborus promediatus* n. sp., habitus of ♀. FIG. 6. *E. similis* (Davis) tarsal claw. FIG. 7. *E. leptonyx* n. sp., tarsal claw. FIG. 8. *E. promediatus* n. sp., egg, posterior view. FIG. 9. *E. promediatus* n. sp., egg, lateral view. FIG. 10. *E. promediatus* n. sp., egg, ventral view. FIG. 11. *E. similis* (Davis) mesonotal flange and axillary tongue, dorsolateral view. FIG. 12. *E. promediatus* n. sp., mesonotal flange and axillary tongue, dorsolateral view.

FIGS. 13-32

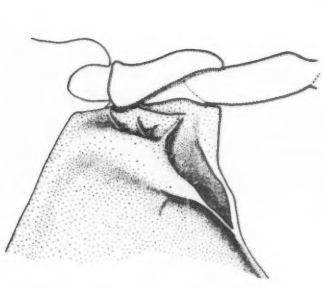
FIG. 13. *E. vitticollis* (Cress.) subgenital plate, lateral view. FIG. 14. *E. vitticollis* (Cress.) genitalia. FIG. 15. *E. vitticollis* (Cress.) ovipositor. FIG. 16. *E. vitticollis* (Cress.) egg. FIG. 17. *E. promediatus* n. sp., genitalia, showing "geniculate" third valvulae. FIG. 18. *E. promediatus* n. sp., ovipositor, one of the "scalaris" type. FIG. 19. *E. glutiniatus* (Roman) third valvulae, ventral view. FIG. 20. *E. glutiniatus* (Roman) mucro, oblique view. FIG. 21. *E. glutiniatus* (Roman) genitalia. FIG. 22. *E. pyelechus* n. sp., ovipositor. FIG. 23. *E. pyelechus* n. sp., egg, lateral view. FIG. 24. *E. pyelechus* n. sp., egg, posterior view. FIG. 25. *E. pyelechus* n. sp., apex of subgenital plate. FIG. 26. *E. pyelechus* n. sp., genitalia. FIG. 27. *E. flavicircus* n. sp., ovipositor. FIG. 28. *E. flavicircus* n. sp., egg, lateral view. FIG. 29. *E. flavicircus* n. sp., egg, posterior view. FIG. 30. *E. flavicircus* n. sp., third valvulae, dorsolateral view. FIG. 31. *E. flavicircus* n. sp., mucro, oblique view. FIG. 32. *E. flavicircus* n. sp., genitalia.

FIGS. 33-63

FIG. 33. *E. eximius* n. sp., genitalia. FIG. 34. *E. eximius* n. sp., egg. FIG. 35. *E. devius* n. sp., mucro, oblique view. FIG. 36. *E. devius* n. sp., subgenital plate, lateral view. FIG. 37. *E. devius* n. sp., valvulae, lateral view. FIG. 38. *E. leptonyx* n. sp., mucro, oblique view. FIG. 39. *E. leptonyx* n. sp., subgenital plate, lateral view. FIG. 40. *E. leptonyx* n. sp., mucro, dorsal view. FIG. 41. *E. nigrocephalus* (Davis), mucro, dorsal view. FIG. 42. *E. nigrocephalus* (Davis), mucro, oblique view. FIG. 43. *E. nigrocephalus* (Davis), subgenital plate, lateral view. FIG. 44. *E. scaphuloides* n. sp., mucro, oblique view. FIG. 45. *E. scaphuloides* n. sp., subgenital plate, lateral view. FIG. 46. *E. similis* (Davis), egg. FIG. 47. *E. similis* (Davis), mucro, dorsal view. FIG. 48. *E. similis* (Davis), subgenital plate, lateral view. FIG. 49. *E. luminosus* n. sp., mucro, oblique view. FIG. 50. *E. luminosus* n. sp., subgenital plate, lateral view. FIG. 51. *E. pulchellus* n. sp., egg. FIG. 52. *E. pulchellus* n. sp., mucro, oblique view. FIG. 53. *E. pulchellus* n. sp., subgenital plate, lateral view. FIG. 54. *E. maculiventris* (Ashmead), mucro, oblique view. FIG. 55. *E. maculiventris* (Ashmead), subgenital plate, lateral view. FIG. 56. *E. promediatus* n. sp., mucro, oblique view. FIG. 57. *E. promediatus* n. sp., subgenital plate, lateral view. FIG. 58. *E. promediatus* n. sp., mucro, dorsal view. FIG. 59. *E. dorsalis* (Cress.), mucro, oblique view (White Fox, Sask.). FIG. 60. *E. dorsalis* (Cress.), genitalia (White Fox, Sask.). FIG. 61. *E. dorsalis* (Cress.), subgenital plate, lateral view (Churchill, Man.). FIG. 62. *E. dorsalis* (Cress.), mucro, dorsal view (Churchill, Man.). FIG. 63. *E. dorsalis* (Cress.), subgenital plate, lateral view (Camino, Calif.).

FIGS. 64-73

FIG. 64. *Orthomiscus leptura* n. sp., genitalia. FIG. 65. *O. leptura* n. sp., ovipositor, dorsal view (to scale). FIG. 66. *O. leptura* n. sp., first flagellar segment (to scale). FIG. 67. *O. platyura* n. sp., genitalia. FIG. 68. *O. platyura* n. sp., ovipositor, dorsal view (to scale). FIG. 69. *O. platyura* n. sp., first flagellar segment (to scale). FIG. 70. *O. platyura* n. sp., egg, ventral view. FIG. 71. *O. platyura* n. sp., egg, lateral view. FIG. 72. *O. leptura* n. sp., egg, lateral view. FIG. 73. *O. platyura* n. sp., habitus.



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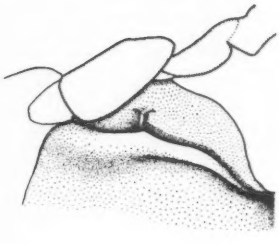

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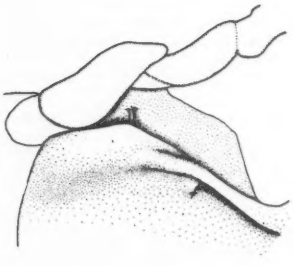

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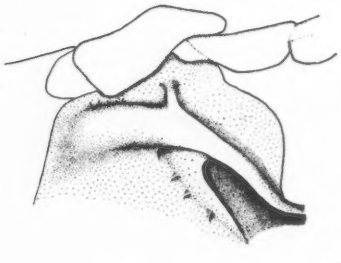

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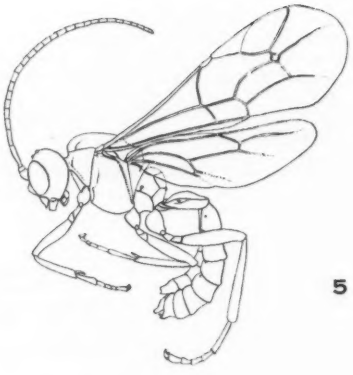

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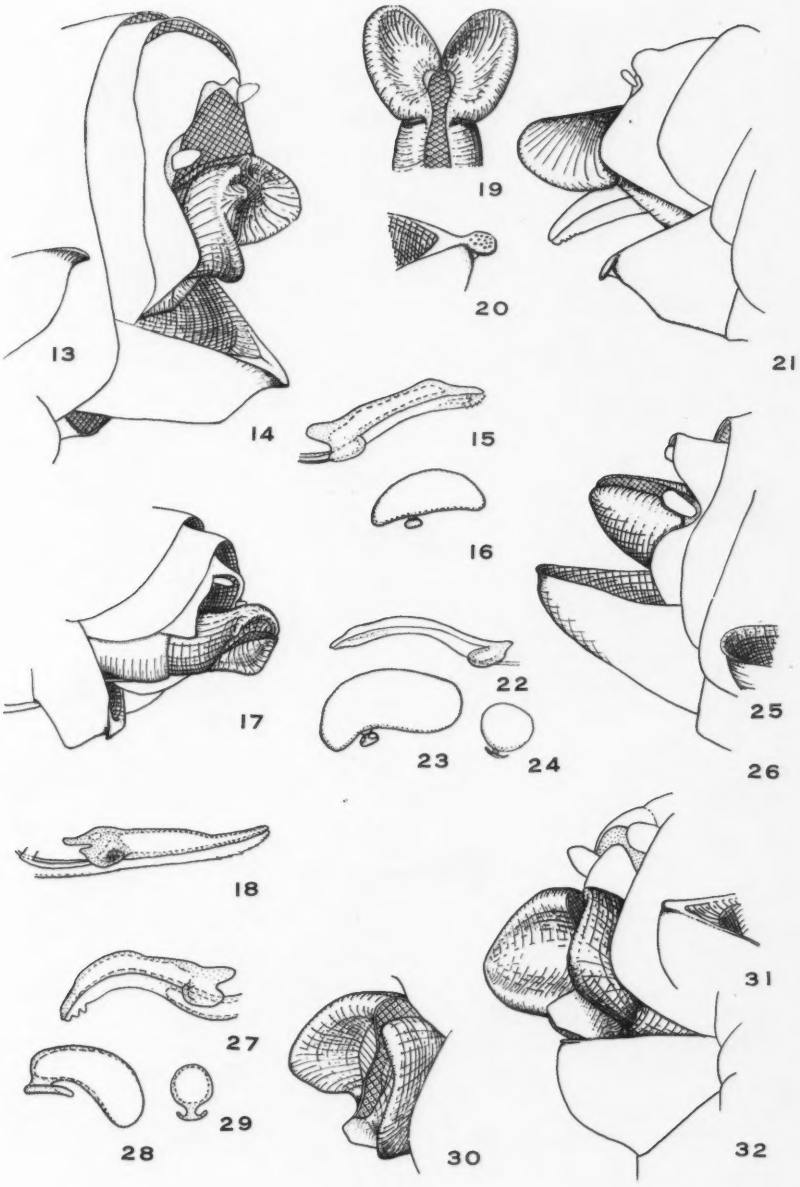
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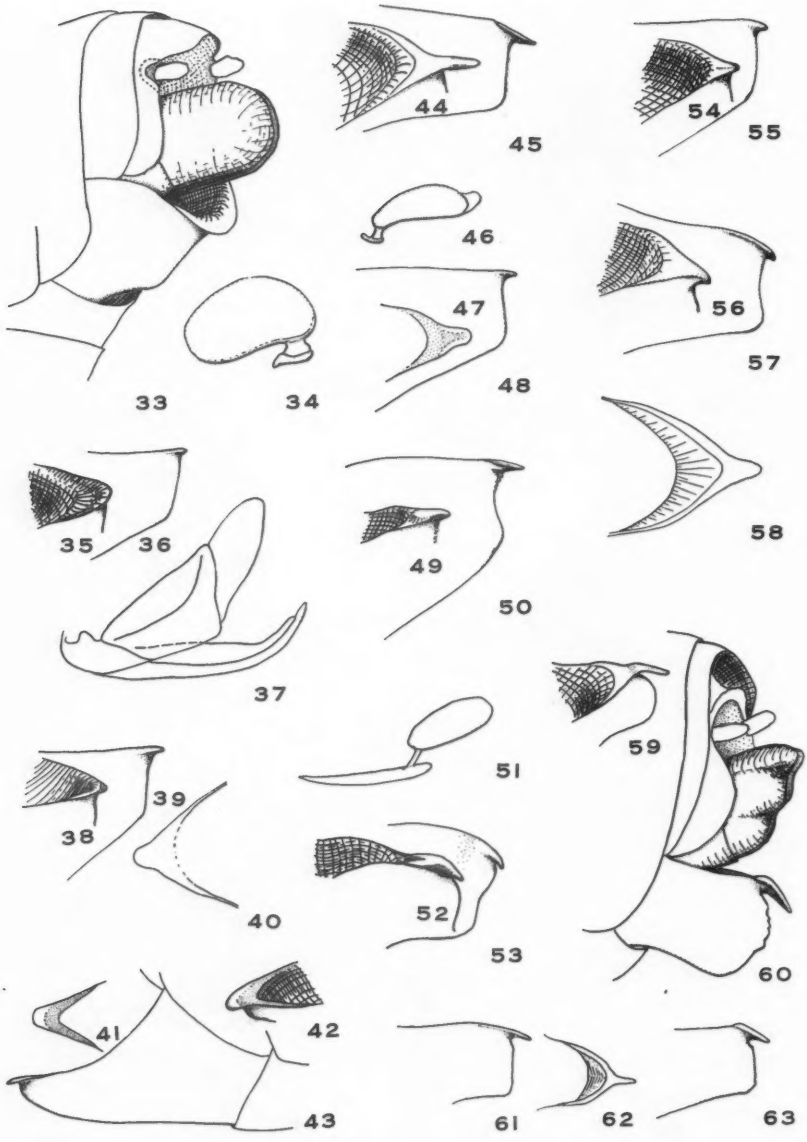
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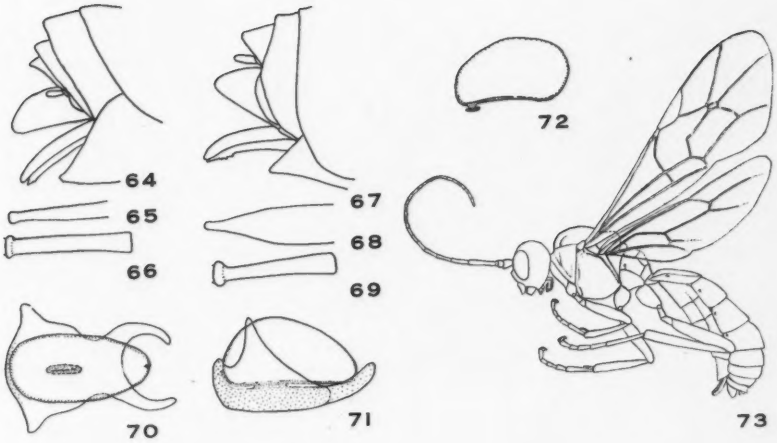
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